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CONTENTS.

	PAGE
Notes and Comments	77
The Employment of Chill Moulds in Foundry Practice	79
Foundry Cupola Practice	83
Sand as Used in the Sand Blast	84
Brazen Gates for an Indian Mausoleum	85
Aluminium and Some of Its Uses	86
The Scientific Mixing of Iron for Castings	89
The Casting of Turbines	94
A New Power Moulding Machine for Small Work	96
The Problem of Bearing Metals	98
Conciliation in the Foundry Trades	99
Moulding Machine for Making Street Lamp Posts	100
Chaplets: Their Use and Abuse	101
Standardising Refractory Materials	102
A High-Pressure Blower for Foundry Work	103
The Baumann Tilting Crucible Furnace	104
The Institute of Metals	106
Technical Education at Cardiff	108
Steel Castings	109
Machine Moulding of Bevel Gears	113
Foundry Tests for Pig-Iron	115
The Court of Arbitration for Industrial Disputes	116
"Fair Wages" in Government Contracts	116
Electric Furnaces for Steel	117
An Improved Sand Mixer and Grinder	118
The "Foundry Trade Journal" Bookshelf	119
Inventions	120
Deaths	120
Queries	122
Replies	122
Prices of Metals	124

FORTHCOMING EVENTS.

FEBRUARY 6.

British Foundrymen's Association (Lancashire Branch).—"The Pattern-maker: His Work and its Relation to Allied Trades," by Mr. Flitcroft.

FEBRUARY 20.

Staffordshire Iron and Steel Institute.—"Pig-Irons and their Use," by Mr. E. Adamson.

FEBRUARY 22.

Birmingham Metallurgical Society.—"Compounds of Metals with Metals," by Mr. T. Slater Price.

FEBRUARY 27.

British Foundrymen's Association (Birmingham Branch).—"The Mixing of Iron for Castings," by G. Hailstone,

NOTES AND COMMENTS.

The Dangers of Ferro-Silicon.

In a recent issue we commented on the dangers of ferro-silicon, and following close upon that comes the news of the death of firemen on board a ship transporting the material, as the result of fumes from the ferro-silicon. The forehold, where the stuff was stored, was found to be perfectly dry.

At the inquest, evidence was given by Mr. J. A. Foster, analytical chemist, of Hull, to the effect that the ferro-silicon contained iron, silicon, carbon, phosphorus, and arsenic. Five gases were given off—namely, arseniuretted hydrogen, phosphoretted hydrogen, acetylene, pure hydrogen, and sulphuretted hydrogen. Pure hydrogen, the witness said, was of an asphyxiating nature, and the other gases were very poisonous, arseniuretted hydrogen being most intensely so, a single bubble having been known to cause death. Phosphoretted hydrogen was nearly as deadly. In less than 24 hours, 9 tons of ferro-silicon, if dry, would give off 110 cubic feet of extremely deadly gas; and if the stuff were moist, thrice that amount would be evolved. The gas given off by the ferro-silicon in the hold would have killed a hundred people. The early symptoms were liable to be mistaken for those of cholera or ptomaine poisoning. The gas decomposed the blood. Ferro-silicon was most treacherous; if sealed in drums it was liable to explode, and if cased in barrels it gave off the poisonous gases mentioned.

The Swedish Government have recommended that in passenger vessels ferro-silicon, if carried, should be on the open deck, and away from cabins, etc. They do not advise packing it in hermetically-sealed drums, for fear of explosion. By railway it should travel in open trucks, covered with water-tight tarpaulin.

Messrs. J. W. Jackson & Company, Limited, Caxton House, Westminster, writing on the subject, say:—

"The recent tragic occurrence on the s.s. 'Ashton,' sailing from Antwerp to Grimsby, when five lives were lost through the poisonous fumes emanating from nine tons of ferro-silicon in barrels, which constituted a part of the cargo, will no doubt cause considerable surprise to many users of ferro-silicon, who have been entirely in ignorance of the dangers of this material. Attention has already been called to the dangerous properties of ferro-silicon by the Board of Trade, and now that these facts have been proved in such a sad way, it is probable that steel-founders will hesitate to use such a dangerous material.

"It may not be generally known that all the qualities for which steel-founders purchase ferro-silicon can be obtained by using carbide of silicon, which is a perfectly innocuous material, and can be used without risk. As most of your readers are probably aware, carbide of silicon is a product of the electrical furnace, and its extreme value to steel-founders will be apparent from the following analysis:—Silicon, 63.30

per cent.; carbon, 26.75 per cent.; alumina, 9.90 per cent.

"The rapidly-increasing demand for this material is a proof that its value is becoming more apparent to steel-founders."

Buying Pig-Iron by Analysis.

The Pittsburg Foundrymen's Association, at a recent meeting expressed its judgment in favour of the buying of pig-iron by analysis. This action preceded a thorough and interesting discussion of standard specifications for foundry pig-iron, in which both foundrymen and furnacemen participated.

Mr. H. E. Field, Chairman of the Committee of the American Foundrymen's Association, who opened the subject, suggested the advisability of establishing a standard base analysis for foundry iron, calling for a fixed content of silicon and sulphur with a sliding scale arrangement which will allow a fluctuation in price by a certain constant, according to variations in the two elements.

The suggestion as to the working out of this sliding scale for iron analysing above or below the base was to allow 25 cents from or to whatever price the contract might call for, according to the respective cases, for each unit of variation in the silicon or sulphur content. This arrangement would in no manner interfere with the market price of standard foundry iron at the time it was bought or during the life of the contract, this being as much a matter of individual settlement as at present.

Mr. Wood, representing the Committee of the American Association for Testing Materials, which is also working for a standard specification of pig-iron, spoke upon the subject. He said the purpose of a standard specification in itself and outside of any contractual relations such as price arrangement, etc., was to afford the foundryman a clear recognition of an iron upon which he could base his calculations according to his individual needs as he knew them.

Mr. E. H. Williams, of the Perry Iron Company, Erie, Pa., spoke on the difficulties from the furnaceman's standpoint of always meeting iron-clad specifications. This followed from a lack of uniformity in the manufacturing process beyond the control of the furnaceman. Mr. Williams believed than any standard specification should be broad enough to cover the variables in the manufacture for which the furnacemen were not responsible.

Mr. Mason, of the Midland Steel Company, Pittsburg, expressed his opinion that the fixing of any standard basis to be of value must be general in its scope, applying to furnacemen and foundrymen in all parts of the country. Other Pittsburg foundrymen and pig-iron buyers who were present gave their views upon the subject. The general opinion of those present was that the standard base to be adopted should range from 1.75 to 2.25 silicon and 0.05 sulphur.

Philadelphia Foundrymen and Pig-Iron Specifications.

The January meeting of the Philadelphia Foundrymen's Association received the report of the special committee appointed a month previous to draw up standard specifications for pig-iron. The Association ordered the report to be printed and distributed and continued the committee for the handling of further matters arising in this connection. The full report is as follows:—

"Your Committee, following the instructions of your Association, have, in drawing the enclosed specifications, abandoned the buying of pig-iron by number. The tables are so arranged that different qualities of pig-iron can be accurately designated by their chemical content. There are three points which, perhaps, it is desirable to speak of.

First—As buying by analysis fails as to a standard for newspaper quotations, it is proposed that there shall be a grade established upon which prices can be based, known as "No. 2," which shall be of a quality of metal similar to the foreign standard grading upon which warrants are issued, this grade to analyse as stated in the specifications.

Second—So that buyers and sellers can readily express the character of the metal they want, symbols have been put after each analysis, the combination of which into one word will express exactly what the buyer desires, thus saving considerable expense in telegraphing. Further, these symbols condensed into a word will be of value when warehousing iron, as the word written into the certificate will accurately describe the iron that is stored.

Third—If a purchaser wishes to split the steps at which silicons vary (0.50 per cent.), the tables are so arranged that he can designate silicons with a difference anly of 0.25 per cent.

Your Committee believes that, with these explanations, the reason for the new departures will be entirely clear and that the tables are so arranged that it will be possible for any one in the foundry business to designate with precision the metal he desires.

Specifications.

Analysis.—It is recommended that all purchases be made by analysis.

Sampling.—Each carload, or its equivalent, shall be considered as a unit. At least one pig shall be selected from each four tons of every carload, and so chosen from different parts of the car as to represent as nearly as possible the average quality of the iron.

Drillings shall be taken so as to fairly represent the fracture surface of each pig. The sample analysed shall consist of an equal quantity of drillings from each pig, well mixed and ground before analysis.

Percentage of Elements.—Opposite each percentage of the different elements a syllable has been affixed so that buyers, by combining these syllables, can form a code word to be used in telegraphing such enquiries as they may desire to make.

CARBON.

Total carbon not less than 3.25 per cent.

Silicon. Per cent.	Symbol.	*Sulphur.* Per cent.	Symbol.
0.50	Ca	0.03	Sa
1.00	Ce	0.04	Se
1.50	Ci	0.05	Si
2.00	Co	0.06	So
2.50	Cu	0.07	Su
3.00	Cy	0.08	Sy
3.50	Ch	Maxima gravimetric method.	
0.25 allowed variation.			

Phosphorus. Per cent.	Symbol.	*Manganese.* Per cent.	Symbol.
Not less than 0.20	Pa	0.40	Ma
0.30	Pe	0.60	Me
0.60	Pi	0.80	Mi
0.90	Po	1.00	Mo
1.20	Pu	1.20	Mu
1.50	Py	1.00	My
0.15 allowed variation.		0.20 allowed variation.	

Example.—Code word Ci-se-pi-ma represents silicon, 1.50; sulphur, 0.04; phosphorus, 0.60; manganese, 0.40. Whenever standards one-half between the standards above are desired, they will be designated by the symbol X. Thus, "Cix" means 1.75 per cent. silicon, or in trade parlance, 1.50 to 2.00 per cent. silicon; and "Cox" means 2.25 per cent. silicon, or in trade parlance 2.00 to 2.50 per cent. silicon. For market quotations a grade shall be assumed to be known as No. 2 analysing, silicon, 2.50 per cent. and over, and sulphur 0.04 per cent. or under."

The Employment of Chill Moulds in Foundry Practice.

By E. Leber.

The prejudice against chill moulds in iron foundries dates from the period of their introduction, and is doubtless due to the conservative spirit that still exists in many places—a spirit that prefers to see loss follow loss, rather than give up old and deeply-rooted ideas for new methods, notwithstanding that the latter are capable of remedying numerous defects in practice and preventing their troublesome consequences. The author has known many instances where large consignments of hydraulic cylinders have been thrown on the maker's hands, owing to hollows in the castings; and the same with engine frames, through porosity in the cross-head guides. In all of these cases the chill mould could have provided the remedy. Even now, there are many large works in existence where the chill mould is unknown, except by name, and the present paper, it is hoped, will have some beneficial result in popularising it.

FIG. 1.—SULPHATE PAN.

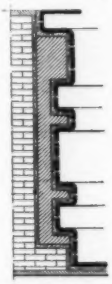


FIG. 2.—TUBBING WITH INLAID SPINDLE.

FIG. 3. ARRANGEMENT OF SPINDLE.

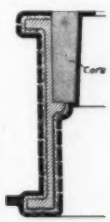


FIG. 4. CASING WITH SPINDLE.

FIG. 5.—FLANGED PIPE.

Owing to its highly divergent effects, the chill mould cannot be described in a few words; but, broadly speaking, the two main factors interesting the iron-founder, and secured by its aid, are the saving in labour in moulding and the influence exerted on the properties of the metal. So far as moulding is concerned, the chill mould constitutes a permanent mould, whilst, so far as the metal is concerned, it can furnish hard or smooth wearing surfaces and prevent cavities and bubbles. However, these two properties of the chill mould cannot always be separated, so that it frequently happens that when the founder lays more stress on one of them, for example, the permanence of the mould, the others—hardening and prevention of cavities—make their appearance as well. Hence it is necessary to adopt suitable precautions to prevent the one influence from adversely affecting the other; to ensure, for instance, that when the compactness of grain has been attained, the casting shall not be spoiled by over-hardness. Since the different influences are, so to speak, interwoven, the applicability of the chill mould cannot be treated systematically, but must be demonstrated by a number of isolated cases illustrating the three chief characteristics, the permanence of the mould, the hardening effect, and the suppression of hollows.

In general, the chill mould may be described as a metal (usually iron) mould, adapted to the shape of casting desired, though occasionally it is divided into two or more parts and surrounds only certain portions of the work. Permanent moulds are also frequently made of firebrick or stamped fireclay, coated internally with a special mixture, such as steel-moulding composition. These are also classed as chill moulds, because their purpose and effect are allied to those of the chill mould proper, and sometimes the two forms are combined for the production of one and the same casting.

Permanent Metal Moulds.

In the so-called spindle method of casting, the chief object of using chill moulds is to have a permanent mould. In this case it is essential that the casting shall not be of highly complex shape, and that the mould shall not oppose the free shrinkage of the piece; and it will be evident that the construction of a permanent mould will be profitable when a sufficiently large number of castings of equal size and shape has to be turned out. Fig. 1 illustrates the arrangement of the spindle for a sulphate-pan. Here the chill mould is in two parts, with sufficient space between them for a facing of loam an inch thick, or 4 in. to 8 in. when sand or moulding composition is to be used. It may also be remarked that, contrary to custom and theoretical considerations, better results are obtained without risers, and with the convex side of the casting uppermost, this method giving a cleaner and more compact bottom surface. Acid pans and evaporating pans of various section are also cast in the same way. The spindle method is highly important in the manufacture of shaft rings or tubbings, for which, as shown in Fig. 2, a combination of brick and metal mould is used. In the case of internally flanged rings, the spindle must be constructed in such a manner that it can be loosened inwardly. The chill mould is built up of three, four, or more parts, according to the diameter of the rings, which may run from 6 ft. to 20 ft. After pouring, and while the metal is still nearly white hot, the parts, *a* and *b*, of the spindle are drawn inward, as shown in Fig. 3, since otherwise the contraction of the casting would render the detaching of the spindle impossible, and the casting would tear. The moulds for wide pipes (casings), parts for gas washers, etc., are prepared in

the same way (see Fig. 4). It should be noted that the outer spindle is made in two parts, whilst the inner portion is in one piece. Immediately after pouring, the two outer pieces of the mould are drawn away laterally, the casting being then lifted out of the mould along with the core.

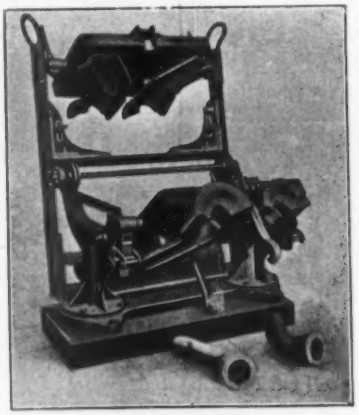


FIG. 6.—MOULDING MACHINE FOR BENT PIPE CONNECTIONS.

To save working, the flanges of flanged pipes are covered with chill moulds (serving as a kind of external core), the moulds being at the same time provided with the packing grooves to be cast in the flange. For the same reason, chill moulds are also used in casting ribbed radiators, candelabra, pillars, and other tubular pieces that are provided with flanges. Similar moulds are used for the central portion of axle boxes, the moulds in this case being slightly grooved to

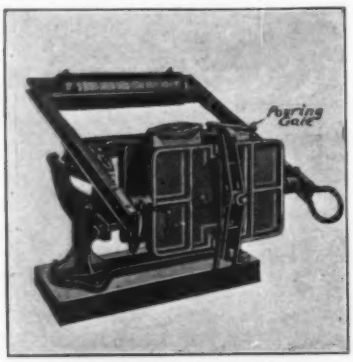


FIG. 7.—MOULDING MACHINE IN POSITION FOR POURING.

facilitate planing. It has now also become the practice to cast brake blocks in chill moulds, the latter being likewise used in the production of castings that are turned out in large quantities, such as cutter-blades and other agricultural implement parts, several moulds being arranged in a two-part chill mould, the halves of which are pressed together like goffering tongs. Bent pipe connections have also been experimentally cast in chill moulds, the two parts of the mould being placed in a moulding and casting machine, as illustrated in Figs. 6 and 7; but this method does not seem to have been adopted in practice. Since, however, the casting of pipes in chill moulds has recently been attempted with success, there do not appear to be any insurmountable difficulties connected with the method in question.

Bricked Permanent Moulds.

These have not met with any extensive application, though they are preferably employed for large, simple castings that are not undercut, and are of nearly circular section throughout. In one foundry known to the author, this type of mould is used for large pans for chemical works, the weights ranging up to 3 tons or more, and about ten pieces can be produced in each mould, all that is necessary after pouring being to clean up the mould and reface it. Articles that can be cast in this way comprise pieces like that illustrated in Fig. 8; standards for vertical engines of circular cross section and inward flanges; drying cylinders for paper-making machines (Fig. 9); press fittings, such as die plates for sheet metal, air-chests, gas-engine cylinders, etc.; and similar moulds have been used for making ingot chill moulds. Although the method offers manifold advantages over the usual practice, it does not seem to have been imitated elsewhere. The cores are prepared in the usual manner, the two-part casting boxes being lined with fireproof material and sleeked. The two halves are held together by iron clamps, which are loosened after each

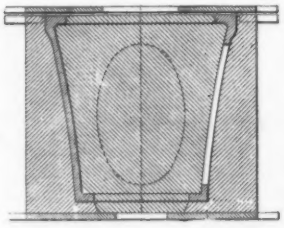


FIG. 8.—INTERMEDIATE PIECE.

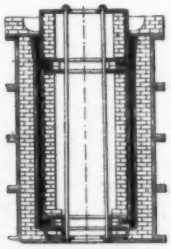


FIG. 9.—DRYING CYLINDER.

pouring, the parts being then sleeked, dried, and got ready for another pouring.

Theoretical Considerations on Hardening and on the Prevention of Cavities and Blow-holes.

The case is different when the direct hardening of a casting is to be effected by means of a chill mould, but, here again, a practical distinction must be drawn between two considerations, since hardening always takes place, though not invariably the object in view. As a rule, chilling produces two genetically connected effects—fine-grained structure and increased breaking strength—though, in most cases, the ironfounder has only one of these results in view when using chill moulds, his aim being generally to improve the physical properties of the casting, though compactness of grain is often the sole purpose desired. Hence, in all cases, one must proceed within definite limits, and take care that the desired strength of the material is not impaired in attempting to obtain a more compact grain, or—in the event of the mechanical condition being a subordinate matter—that the workability of the casting be not endangered. For a given pouring temperature, three factors come under consideration: (1) The composition of the iron; (2) the thickness of the casting; and (3) the thickness of the chill mould. Of course, it is necessary, above all, to observe the known rule that chill moulds should not be used for highly manganiferous iron. The thickness of the chill mould may be reduced in proportion, as the attainment of the desired compactness of grain is facilitated by the absolute and relative proportions of carbon and silicon. On the other hand, the silicon

content should be raised in proportion as the walls of the casting diminish in thickness. Where great strength of metal, combined with ease in working, is desired, considerable care is necessary in producing thin walled castings, so as not to exceed the proportion of hardening carbon that will give the right physical properties without making the metal too hard for the tools. Though it is undesirable for any obscurity to exist with regard to the limits influencing the various possibilities, no fixed ratios can be laid down, unconditionally, respecting the chemical composition of the iron and the relative thickness of the chill moulds and the walls of the casting, the author's experience being that under equal conditions two different samples of iron, of almost identical composition but different origin, behave differently when cast in chill moulds. Hence it is essential that the ironfounder should be fully acquainted with the metal he has to deal with, and should make tentative experiments in all doubtful cases. Generally speaking, however, there is no need for undue anxiety, the limits of the applicability of chill moulds being indicated by the purpose in view and the conditions laid down. Thus, in the case of grey castings, for which a fine grain is the sole criterion, chill moulds are used in order to obtain a smoother outer surface and increased polishing capacity, without making the metal difficult to work.

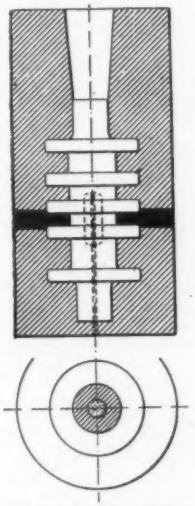


FIG. 10.—FINISHING ROLL WITH CHILL AND CORE.

FIG. 11.—ROLL WITH EMBEDDED PIPES, ETC.

FIG. 12.—ROLL WITH EMBEDDED COOLING PIPE.

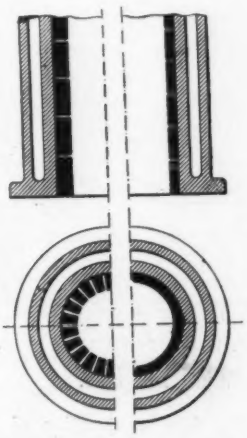


FIG. 13.—CHILL MOULD WITH CHILL BLOCKS.

FIG. 14. ANNULAR CHILLS.

The necessity for increased care is first forced upon the ironfounder when he is constrained to employ chill moulds for the purpose of preventing cavities in his castings, more especially since it is not always practicable for him to select the most suitable metal to use with chill moulds. In the case of ordinary machinery castings, no special difficulty arises, as the metal will almost always stand such action of the chill moulds as is needed for obtaining a fine grain in certain parts, even when the metal is to be worked afterwards. With special castings, however, the case is different, some cylinder metal being unable to bear the application of chill moulds to any parts that are intended to be worked, without running the risk of tearing, or of forming white patches that the tools will not touch. Still more susceptible are cylinder linings, and all kinds of castings produced from metal that has been compounded with a view to obtain compact structure, combined with ease in working and high breaking strength. If it be necessary to employ chill moulds in such cases, it must not be forgotten that their effect should be merely local, that the general equilibrium of the stresses set up in the casting must not be disturbed in any part and the internal cohesion of thicker parts of the casting endangered. Above everything, chill moulds must not be applied to any parts that are to be worked, unless in urgent cases, and the parts can be ground instead of turned. From these considerations it is evident that the use of chill moulds is frequently an emergency resource, and that a preliminary trial is always advisable. With a metal composed of 1.0 per cent. of Mn and over, 0.8 per cent. of P and over, 1.6 per cent. or less of Si, and 3.2 per cent. or less of C, it is desirable that no chill moulds should be used for any parts that are to be worked.

Hardening.

To illustrate the foregoing considerations in respect of hardening, a number of practical examples may be given. The simplest application of chill moulds in the production of hardened castings is exemplified by firebars, press cheeks, and other parts of preparatory machines, the chill mould acting as the bottom box. Plates for edge-runner mills are cast on hardening plates, and the rims of the runners are also hardened, the mould being built up of segments that are suitable for all the current sizes. Small gauge truck wheels and certain other wheels (Griffin wheels, for example) are cast in chill moulds; but the most usual example of chill mould casting is afforded by plain rolls for sheet iron rolling mills, these being simply cast in a permanent iron mould. In some cases the shaped rolls for the finishing passes are also cast in chill moulds (Fig. 10). In order to prevent the tearing of the metal, the chill rings must have a perfectly smooth inner surface. In the case of upright moulds, the chill ring is turned on the inside, and is provided with breaking joints, but with horizontal moulds two half-rings are used, these being worked on the inner faces and at the contact surfaces. The danger arising from the mutual hardening effect of the chill mould and metal may be gauged by the means adopted to

prevent the tearing of the rolls. Thus, in some instances, an ordinary sand core is inserted at the danger zone (Fig. 10), or a pipe with radially branching rods is cast into the roll (Fig. 11). Fig. 12 shows a roll, into which is cast a pipe that can be connected with a water pipe for cooling the casting; but it is doubtful whether this means is really efficient. An instance in which chill moulds are used for the express purpose of hardening as well as producing compact structure, is afforded by gas engine cylinders, it being impracticable to meet the high requirements demanded of the inner surface of these cylinders by modifying the composition of the metal alone. Hence the surface must be chilled by facing the core with iron blocks (Fig. 13), or in some cases with alternating layers of iron blocks and brickwork, or again, by embedding chill strips at certain intervals in the outer wall of the core. In some foundries the inner face of the cylinder is cast on a chill core, consisting of a number of iron rings, shaped like piston rings (Fig. 14), and held together by a screw spindle. To enable these rings to be easily taken out of the mould after pouring, they are provided with breaking

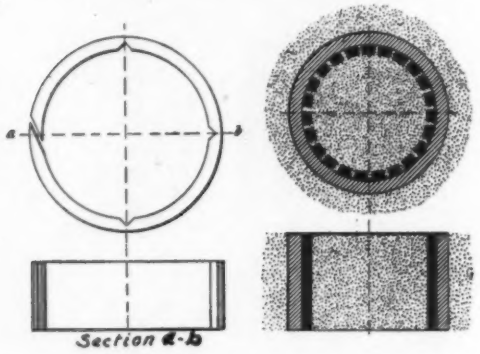


FIG. 15.—RING CHILL WITH BREAKING JOINT AND SLIT.

FIG. 17.—CHILL RING IN THE MOULD.

joints, the free contraction of the casting being facilitated by slits in the rings (Figs. 15).

Compact Grain.

Plungers (Fig. 16) form a typical example of castings that required to be fine in grain and fairly strong, without any special hardness. In order to protect the pump washers from injury, the plunger surface must be perfectly smooth—a condition that often gives the ironfounder considerable trouble, more particularly on account of the large dimensions of the castings. The chill mould, however, effects without difficulty, results that cannot be obtained from the composition of the metal alone, and enables perfect plungers to be cast up to a height of about 24 ft., a diameter of 40 in., and a thickness of 12 in. of metal. Many of these plungers are made of steel castings, but, for medium and low-pressures, the pump-maker usually prefers them of iron, both on account of their lower cost and greater chemical resistance. Hard metal is too expensive and troublesome for the ironfounder, and there is always the risk of the castings getting out of true when worked owing to the formation of hard places, due, not as often assumed, to "unmelted" portions of the steel, but to the local enrichment of the metal to form white iron, which will not mix with the rest. Instead of adding, as formerly, up to 30 per cent. of steel to the metal, better results can now be obtained by ordinary machinery iron and chill moulds. Fig. 16 shows a plunger mould fitted with chills, the latter formed of conical segments the thickness of which depends on the dimensions of the plunger and the depth to which the metal is to be chilled. Brick facing, of varying width, is inserted between the segments, so that a uniform surface is produced, without zones, on the plunger, and the grain is fine all over. With plungers of 8 in. thickness of metal, and chills 4 in. thick, the face of the plunger will be of fine grain to a depth of an inch, though of sufficient softness to work with ease.

Still better results are obtained with chill moulds in the case of piston rings, which are required to be soft, in order that they may not injure the inner surface of the cylinder. The breaking strength need not be high, but the rings must be elastic, take a perfect polish, and

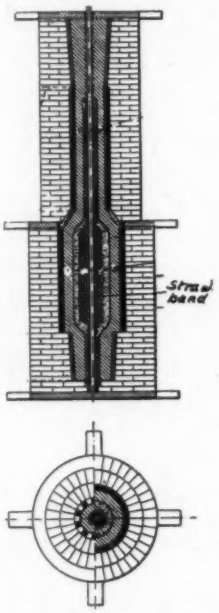


FIG. 16.—PLUNGER.

be easy to work, all of which conditions can be obtained by the use of ordinary machinery iron, provided the chill moulds be applied in a suitable manner. The moulding is an easy task. The pattern is placed on the bed-plate, and chill rods are driven into the floor at suitable intervals round the inner wall of the pattern (Fig. 17). The core is filled with rammed sand, and the outer box is made ready in the usual way. After removing the pattern and mould box the spaces, filled with sand, between the chill rods are sleeked. Large rings, up to 32 in. diameter, are preferably poured from two ladles through tangential gates (rotary pouring). The chills being on the inner side, that portion of the metal acquires the greater tension and the requisite elasticity; whilst, on the outside, the metal is softer and easily workable, though perfectly compact and very smooth. Care must be taken, in driving in the chills, that the rods are close enough together, or the opposite effect will be obtained, and loose places, extending right through the metal, will be produced between the rods.

(To be continued.)

Foundry Cupola Practice.*

THE DESIRABILITY OF SMALLER CHARGES.

By Richard Moldenke.

In the last few years a good deal has been written on the subject of imperfect castings and many and varied have been the reasons advanced to account for the existence of pin, gas, and slag holes, interior shrinkages, draws, cracks, and the like. The supposition that these undesirable manifestations are solely due to moulding troubles, bad sand, air in the moulds which cannot escape fast enough, bad design, or an improper mixture of metal, does not always convince the experienced foundryman.

For years it has been my opinion that apart from causes easily seen and remedied, the difficulty in nearly all cases of imperfect castings lies deeper, and may be found directly in the manner in which the charge of metal is melted down. In other words, there is something about every melting process, whether cupola, air furnace, or open-hearth, that must be taken into account, otherwise a greater or less number of the castings made will show spongy spots, pin holes, etc., when machined

Several years ago very elaborate cupola melting tests were made at the Government testing plant in connection with the St. Louis Exposition. I was in charge of this work and present at nearly every individual test, and hence could observe the peculiar behaviour of the several cokes tested out. A large number of cokes made on the premises from coals gathered all over the country, and selected specially for their probable usefulness for foundry purposes, were run through two small cupolas under standard conditions and the results noted.

Reduction in Melting Time.

Melting in the crucible has always given the best results, and simply because the oxidising influences are at a minimum. In the air furnace proper attention to the melting, and doing away with the thin edge of molten metal on the sand bottom by making this approach the open-hearth shape more, does away with much of the oxidation resulting in weak metal. In the open-hearth, as well as the air furnace, the reduction of the time in melting does more than anything else to keep the quality of the metal up.

In the case of the cupola things are more complex. It is necessary to see what function each part of the operation serves. Take the coke bed; this may be divided into three parts. The first is that portion below the tuyeres which serves as a filling. It occupies the space intended to hold the molten iron, and holds up the balance of the charges. The second portion of the bed is that just above the tuyeres and up to the zone of melting. In this space the blast has its oxygen more or less converted to carbonic acid and carbonic oxide. The third portion is the incandescent coke at which the actual melting takes place. The second and third portions of the coke, of course, shade into each other, the temperature of the coke rising from the comparatively dull heat of the bottom filling to the hottest part of the melting line. As the metal melts this line—if it may be so called—naturally drops downward, and when all of the first charge is gone the first intermediate coke charge gets on the bed, bringing it upward again. The second charge of iron is melted, the bed dropped in so doing, and again the next intermediate coke charge brings it up—and so on. On the nicety of the charges depends the rate of melting, the melting loss and a number of other things.

That practically only the portion of the coke above the tuyeres does any melting is proved by the fact that in many foundries, where it is not desired to hold any metal in the cupola at all, the tuyeres are placed a few inches from the bottom. Again, that the lower portion of the coke above the tuyeres is also not effective for good is shown by the damage done when the iron gets too low. Hence the upper part only of the coke charge should be counted as effective, and study be given it to see how it can be made most so.

The Effect of Heavy Charges.

If only the upper part of the coke bed does the melting, and this part, being used up in so doing, is replaced by the small coke charge above, why is the first charge in cupolas made heavier than the rest? It seems unreasonable, in fact, absolutely incorrect to do so. Iron does not begin to melt until the coke has burned down to the proper point. It takes more coke burned away after melting starts to care for a big first charge than for a little one, such as those subsequently used. Therefore, with the big charge the coke bed has been lowered so much that the subsequent coke charge does not restore the bed to its original height; in fact, far from it. The second iron charge, therefore, does not begin to melt where the first one did, but much below it. The result is burnt iron in both cases. This goes right on for every succeeding charge, the latter end of each being too low and near the blast, which at this low point contains a lot of unconsumed oxygen. Usually we find that the intermediate coke charges are just a little larger and gradually the line of melting is brought back to where it should be, and hence the burning trouble is confined to the first part of the heat. One often hears that toward the end of a heat the iron comes slow, and by reducing the coke in the last charges a little, quicker results are obtained. This is simply due to the extra large coke charges bringing the bed above the melting line, and hence coke must be burned away to get the iron into the proper place again for melting. The conclusion that one must come to, if the reasoning is correct, is that the first charge shall be no larger than the others succeeding.

Moreover, if the unreasonable fluctuation of the melting zone produced by an excessively large first charge does damage to the metal, then why not make all the charges not only alike, but as small as it is possible to make them, in order to hold the melting line as constant as possible. Herein lies the change I suggest in cupola practice, as it is carried on to-day. I have tried this method repeatedly in the last year with remarkable results, nearly all the imperfections mentioned being wiped out wherever the charges were made very small. The bed is started off at the right height and the intermediate coke charges proportioned in such a way that uniform melting results throughout the heat, it being assumed, of course, that

* Abstract of a Paper read before the American Foundrymen's Association and the Philadelphia Foundry Fo. emen's Associatio

the chemical composition is correct and that charging and melting are accomplished with care.

Smaller Charges.

The bed may be accepted as of proper height when iron comes at the spout in 7 to 10 minutes, the latter time being preferable. The charges are made so small that the coke between just covers them and no more. The ratio of iron and coke is kept just the same as previously in starting off this way, except that after deducting the coke for the bed from the sum total of coke charged, all the iron and all the coke left is divided up into equal and small charges. After running a while it will invariably be found that the coke can be reduced somewhat, as the small charge system keeps the melting so uniform that the fuel formerly used in making slag and keeping it hot, is applied for melting iron.

It may be of interest to say that with cupolas of about 54 in. inside diameter the metal charges have been made as low as 750 lbs. each, and with admirable results. In general, however, it is well to be guided by the coke between the metal charges, keeping this down to the smallest convenient amount. In this way there is a quick succession of coke layers to keep the bed right up to the proper level. In no case is the metal charge so large that the melting line is lowered very materially, and hence a minimum of iron is burned. The consequence of this is the practical wiping out of pin holes, the removal of draws, gas pockets, lessening of strains which mean cracks, and the closing up or rather prevention of spongy metal. All this, of course, not in its entirety, but in a great a measure.

I need not call attention to the greater uniformity in the mixture attained by this small charge method. This alone would commend it to the smaller jobber, who oftentimes has either no bull ladle or a very small one, holding, say, half of a charge only.

My own suggestion for charging a cupola, especially for big heats, would be somewhat on the following line: Have the cupola cut off 6 in. above the platform, and arrange a hood further up to draw off the gases. (This, I believe, is done in England in some places.) Have a large cylinder of the inside diameter of the cupola and provided with a drop bottom. Place the charges for the cupola inside this cylinder, or several of them, laying the metal, scrap and coke evenly and carefully. Do this in your metal yard. Then transport to the cupola, run directly over it by some overhead method, and drop the charges squarely into the cupola. This will reduce the platform labour to next to nothing, allow the charges to be weighed and laid right, and mean only the handling in the yard.

Sand as Used in the Sand Blast.*

By W. S. Reed.

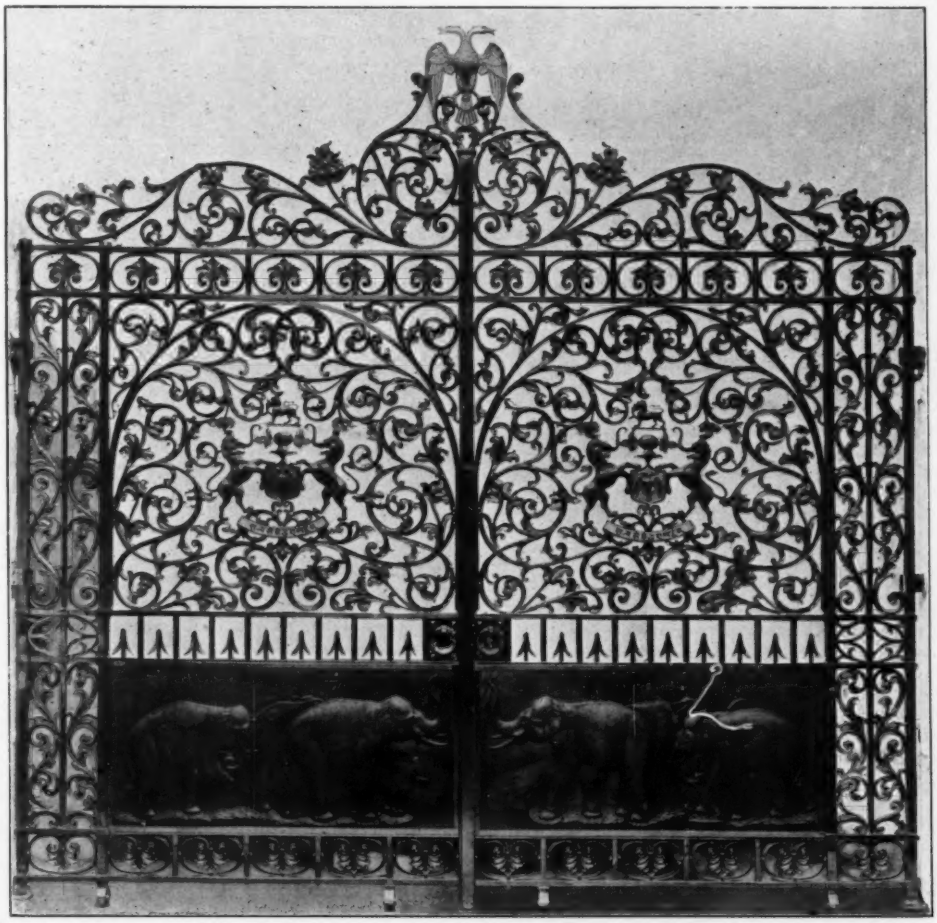
The sand blast apparatus has become one of the important adjuncts of the iron and steel foundry in the cleaning of castings. It does the work much more effectively, economically, and in less time than the old method of the scratch brush and tumbling barrel or rumbler. In the old method the more prominent projections of a casting were more thoroughly cleaned than the smaller and more intricate parts of the pattern, and the sharp or more prominent parts of the casting were liable to become chipped and small castings broken. Sand blast also has the advantage of giving an even colour to the casting, thus more readily showing up any defects. It presents a better surface for painting and has the advantage of removing all the sand adhering to the surface of the casting from the mould, presenting a much more easily worked face for machining, especially parts cast against cores. This freedom from all sand is an important matter in the case of malleable work, as the presence of any sand in the casting greatly interferes with the annealing process. The use of the sand blast in cleaning architectural or structural iron work is one of the most effective methods that can be employed where paint is to be applied, as it presents a raw surface of the metal, so that the paint can enter readily into the pores. It is economical in the fact that iron work so cleaned will stand much longer without repainting. In so using the sand blast the painter should work beside the sand blast operator, as oxidation of the metal commences immediately and is the cause of paint scaling. The sand blast is effective in renovating the fronts of buildings, especially so in the case of stone structures which have been damaged by smoke stains from fires, etc. The hardest materials are the most rapidly attacked, while soft or elastic substances, like rubber, blotting paper, and even the human skin, are either not at all or but slightly affected. One more important use of the sand blast is in the cleaning of iron plates to be used in sanitary ware, which are to receive a coat of enamel. The enamel adheres much better to a surface cleaned with the sand blast than one cleaned by the old slow process of pickling. In operating the sand blast in foundry work it has been found that a large volume of air at low pressure, 15 lbs. to the square inch, is far more economical than a small volume at high pressure. The sand blast requires a perfectly clean sand, preferably kiln dried and shipped dry in box cars. It must be a quartz sand, but of sedimentary origin; that is, a sand that has been derived from sedimentary rocks. Such a sand has been found, from the writer's experience, to be tougher than the sand from original crystalline quartz rocks. While the latter is harder it is more brittle and will not last as long in the machine. Glass is very hard, but is of no use whatever in the sand blast, as it is too brittle, as are all sands of a highly developed crystalline structure. The sands for this purpose are supplied in four sizes of separations according to the character of the castings. A No. 1 sand, about 1.0 mm. in size of grain, is used for small castings and stove work. No. 2 sand, about 1.5 mm. in size, is used for medium sized castings and plate work. No. 3 sand, about 2.00 mm. in size, is used for large steel castings. Some few foundries use a gravel the size of a large pea. The specific gravity of this sand should be as high as possible—2.63 to 2.65 plus, as the sand acts as a hammer; it is essentially an impact blow rather than abrasion, notwithstanding the popular impression to the contrary.

* Abstracted from a Paper read before The Engineers' Club of Philadelphia, U.S.A., and published in the "Proceedings."

Brazen Gates for an Indian Mausoleum.

A Remarkable Piece of Birmingham Foundry Work.

Birmingham has attained some celebrity as the producer of high-class metallic work for foreign nations, and among recent achievements one of the most striking is a pair of brass gates, of which we



are able to give a photograph, manufactured by Messrs. Tonks, Limited, brassfounders, Moseley Street, Birmingham, to the order of the Maharajah of Mysore. The massive production is intended for a Mausoleum entrance, and each gate weighs approximately a ton and a-half. The dimensions of the gates are from 170 to 175 square feet, and the upper portions consist of rich ornamentation in the form of scroll work of Indian design. Each gate is decorated with the potentate's crest, a splendid example of metallic art. On either side the crest exhibits rampant lions, and though the general outline, including the mouth, is clearly leonine, the animals are each equipped with an elephant's trunk. Surmounting the lion is an Indian buffalo, and between the animals is a double eagle representation. Below these is some Sanscrit lettering, whilst on the lower panels of the gates are striking illustrations of elephants.

As an achievement in the way of casting the gates are exceptional. The scroll work was cast in pieces, and hard-soldered together. The richly lacquered brasswork makes a very imposing appearance, and the representations are the same on either side of the gates. They are hung on hinges manufactured of phosphor-bronze, gunmetal, and steel, with a steel cone-shaped centre-pin. The gates are to be opened by a roller arrangement, and so perfectly balanced that either of them can be drawn open by the little finger. The gates will harmonise very effectively with the white masonry of the Mausoleum. The whole scheme was worked out by the firm merely on verbal suggestions from the Maharajah, which the artists developed into a drawing and sent for the potentate's approval.

Aluminium and Some of Its Uses.*

By J. T. W. Echevarri, M.I.Mech.E.

Aluminium, although discovered as far back as 1827 by the German chemist, Woehler, was not used to any extent till the electrolytic method of extraction, invented simultaneously by Héroult in Europe and Hall in America, enabled it to be produced on a commercial scale and at a price comparable with the other common metals. Since then improved methods of manufacture have enabled the price to be still further reduced, till to-day aluminium is, bulk for bulk, one of the cheapest of the common metals. The following table shows the steady fall in price during the last twenty years:—

Price of Aluminium per ton.

	£
1889	3,256
1891	812
1892	495
1896	163
1901	130
1905	130 to 170
1907	200 to 106
1908	100 to 65

On its first appearance the new metal was hailed as a panacea for all the ills the metallurgist is heir to, and its use was proposed for every imaginable purpose, from armour plate to chemical chambers, and it was this very exaggerated idea of its scope of usefulness which in the end militated against its employment for those purposes for which it is most suited, for its failure to stand up under obviously unsuitable conditions led to a general distrust in the new metal, which it has taken years to live down.

The enormous demand and consequent high price of aluminium during the copper boom of 1906-1907 also seriously affected its development; as many of those who would have been glad to use the metal were forced by its rising price to give up their projects or to turn their activities in other directions. This large demand, however, induced the manufacturers to lay down increased plant to turn out the metal in large quantities, the benefit of which we are to-day reaping in the very low price at which the metal now stands.

Manufacture.

Aluminium is now obtained electrolytically from bauxite, a clay containing a high percentage of aluminium oxide, cryolite being used as a flux. The chief improvements that have been effected since this method was first employed lie in the exclusion of the impurities contained in the raw material, for whereas formerly commercial aluminium rarely contained more than 98 per cent. of aluminium, most of that turned out by the British Aluminium Company, Limited, to-day carries close upon 99½ per cent. of aluminium, whilst metal with as little as 0.4 to 0.3 per cent. of impurities is obtainable for special purposes. For ordinary requirements, however, such high degree of purity is unnecessary, and does not repay the extra cost of manufacture.

Impurities.

The impurities commonly met with in aluminium are iron, silicon, and sodium. Silicon renders aluminium very brittle if present in large quantities, and this drawback does not appear to be offset by any corresponding advantage. Silicon also impairs the resistance to corrosion peculiar to pure aluminium, promoting the decomposition of the metal. In this connection it is interesting to note that the thin yellow coating which forms on the inside of cooking utensils is largely composed of silicon. In high-grade aluminium the percentage of silicon should in no case exceed 0.4 to 0.5 per cent., although the metal as used in iron and steel works may contain double this amount with impunity.

Iron occurs in high-grade aluminium to the extent of about 0.2 to 0.3 per cent., and whilst somewhat impairing the ductility of aluminium in the same way as silicon, the tensile strength is somewhat improved by its presence in small quantities. The presence of iron does not appear to affect the electric conductivity of aluminium to the same extent as silicon, but has a bad influence on its non-corroding properties. Sodium is the most injurious impurity to be found in aluminium, as the resistance to corrosion is seriously lowered by even small quantities of this metal. Improved methods of manufacture have, however, eliminated all but the minutest traces of this element, till to-day more than 0.006 per cent. of sodium is rarely found, half this amount being the more usual figure.

Physical Properties.

The pure aluminium of commerce is a silver white metal, with a melting point of 657 degrees C., and a specific gravity ranging from 2.56 to 2.72, according to its method of treatment. Copper having a specific gravity of about 8.8, zinc about 6.9, and tin about 7.3, it follows that aluminium is about 3.3 times as light as copper, 2.5 times as light as zinc, and 2.7 times as light as tin. The heat conductivity of aluminium is high, being second only to copper among the common metals in this respect. Its electrical conductivity is also high, being from 60 to 62 per cent. of that of pure electrolytic copper; it having like copper a somewhat lower resistance when soft than when hard drawn.

Mechanical Properties.

The strength of pure aluminium depends to a large extent on its method of treatment, but the following table gives average figures for the metal in various forms in tons per square inch:—

	Ultimate tensile strength.	Yield point.	Elongation %.	Modulus of elasticity.
Sand castings ...	5.0	2.5	25	—
Chill castings ...	5.25	2.5	35	—
Rolled bars... ...	7.0	5	35	—
Rolled sheet ...	9.0	8.5	6	—
Drawn sections ...	8.75	8.5	20	—
Hard drawn wire...	15	13	25	9,000,000
Soft drawn wire ...	7	4	30	10,000,000

Methods of Working.

Aluminium may be melted in ordinary plumbago crucibles over a coke fire, but where quantities are to be melted a reverberatory coal furnace is generally used. The metal should not be heated above 725 degrees C., to avoid "burning," as at this temperature aluminium readily oxidises with the oxygen in the air. Sheet metal can be re-melted by submerg

* Read before the Institute of Metals.

ing in the molten metal, the loss being only from 2 to 3 per cent., which is much lower than in the case of brass and similar metals.

Aluminium can be cast in either sand or chill moulds, the latter method being generally employed where a good finish is required on small plain castings. Aluminium cast in polished steel moulds has a finish equal to the best machined surface. For rolling it is cast into large slabs or blocks which are afterwards broken down hot, the intermediate and finishing stages being done cold, the amount of annealing being governed by the temper and finish required.

Aluminium can be easily drawn into sections, tubes and wires, more or less the same methods being employed as for copper. The billet is first rolled down hot to a convenient size, and afterwards reduced to the correct section on the drawbench, cold fat being used as a lubricant. For drawing down to the finer gauges in the wire-drawing machines, paraffin is employed as a lubricant. The amount of annealing during the process depends upon the temper required. Wires from $\frac{3}{4}$ in. down to 0.018 in. diameter can be drawn in this manner, these being used for practically all purposes where copper, brass, or German silver wire is used.

Sections, rods and tubes in aluminium can also be made by forcing the solid metal, at a temperature of about 80 degrees C., by means of hydraulic pressure through suitable dies, this method being economical only where a great number of lengths of the same section are required, owing to the cost of the plant necessary. Soft aluminium sheets can be spun, stamped, or pressed into various shapes, cocoanut oil or other lubricant being used.

For turning, a sharp-edged tool with a good clearance should be used, and the work run at a very high speed combined with a slow traverse, plenty of lubricant in the shape of soap and water or paraffin being used. For drilling holes a diamond or nose drill with ample clearance should be used, a twist drill being liable to seize. Screw threads can be cut with an ordinary tap, using a little light oil as a lubricant.

Aluminium can be soldered by means of the various special solders now on the market, but as such soldered joints are all more or less subject to electrolytic action in the presence of moisture, they are only suitable when protected from damp air. Welded joints, being entirely of aluminium, do not suffer under these conditions, and this method is being more extensively used now that satisfactory welded joints can be made by means of portable oxy-acetylene blowpipe equipments.

It had long been recognised that this was the most hopeful direction in which to experiment, because such joints, containing as they do nothing but aluminium, would be as free from electrolytic action as the metal itself, but the difficulty met with was in getting rid of the film of oxide, which prevented the two surfaces uniting properly. In the case of the butt welding of small rods and wires, this difficulty can be easily overcome by applying end pressure at the moment of fusion to drive out the film of oxide, but in the case of sheets and plates this method is not practicable, and recourse had to be made to some other method. Lately several fluxes have been put on the market capable of dissolving the film of oxide and permitting the metal to flow together with perfect ease. Another method of welding aluminium sheeting which shows promise of success, and which would repay further investigation, is the electric system of welding, by means of so-called spot welders; this method being extensively used for copper and iron sheet. The electric welders as used for copper and iron wire are also suitable for aluminium wire with certain modifications.

Applications.

Iron and Steel Works.—Aluminium is used in iron and steel works for removing the oxygen from the oxides of iron, and many other substances, with which it comes in contact, the heat generated by this reaction being so great that it may be also of service in raising the temperature of large bodies of iron.

The efficacy of small quantities of aluminium in preventing "porosity" is also very marked. Porosity is due to the partial disengagement of gases absorbed during melting, which are imprisoned as the metal cools. Aluminium appears to have the property of combining chemically with these gases and producing an innocuous slag.

It frequently arises in small works that a casting requires two "blows" of the cupola. In this case the difficulty of keeping the first tapping hot while the second charge is running down may be readily overcome by adding from time to time small quantities of aluminium to the metal in the ladle. The rise in temperature obtained effectually prevents the metal from excessive cooling.

For the purpose described, the metal may be employed in various forms. An alloy known as ferro-aluminium, consisting of about 90 per cent. of iron and 10 per cent. of aluminium, is used by many iron and steel founders, this material being so brittle that it is a simple matter for the user to break off the right amount to suit his own requirements. The use of ferro-aluminium has, however, been largely superseded by that of the pure metal, which is generally supplied in the form of notched bars and half-round bars, easily cut up into small pieces for use.

Some steel-makers use aluminium in a form known as "granulated." This consists of a powder which may vary in coarseness from that of rice down to that of sifted sugar. Where the heating effect of the burning metal is alone required granulated aluminium may be profitably used, and is generally mixed with sufficient smith-scale to provide the oxygen necessary for its combustion.

The makers also supply iron and steel founders with aluminium in small uniform pieces weighing exactly $\frac{1}{8}$ oz. and $\frac{1}{4}$ oz. each respectively, so that the user is saved all trouble of weighing, and can add any predetermined percentage of aluminium to his iron or steel with a minimum of delay and inconvenience.

A further application of this principle has been made in the "Thermit" welding process invented by Dr. Goldschmitt, where the heat of combustion of aluminium and oxygen is made use of to raise the temperature of iron and steel castings, etc., to the welding point.

Aluminium Castings, etc.

Aluminium is used for many purposes in the building of motor cars, where stiffness combined with lightness is desired. Among these may be mentioned crank-cases, gear-boxes, carburettors, radiators, and dashboards, besides many small details, such as control levers, lubricators, etc., and it is, besides, finding a large and increasing outlet with engineers, brass-founders, and others, for a variety of general castings.

For castings, it is found of advantage to alloy the metal with copper, zinc, or nickel, which increases the strength and makes it easier to work, without materially increasing the weight.

Sheet Aluminium.

When rolled into sheet, the uses of aluminium are too numerous to mention, as the light metal is every day finding its way into new channels in competition with older metals. The reason for this will be easily

seen when it is remembered that at to-day's prices a rolled sheet 6 ft. by 3 ft. by $\frac{1}{16}$ in. thick, having an area of 18 square feet in—

Aluminium	weighs	16 lbs.	and at	1s. 1d.	per lb.	costs	17s. 4d
Brass	,,	49½ lbs.	,,	0s. 6½d.	,,	,,	26s. 10d.
Copper	,,	52 lbs.	,,	0s. 7½d.	,,	,,	33s. 7d.
German silver	,,	50 lbs.	,,	1s. 2d.	,,	,,	58s. 4d.
Pure tin	,,	42½ lbs.	,,	1s. 5d.	,,	,,	59s. 10d.

Other thicknesses of sheets, tubes, rods, beadings, mouldings, angles, channels and other sections will, of course, be in similar proportion.

In the early days of aluminium, sheets composed of copper alloys were used to some extent in connection with shipbuilding. It has, however, since been demonstrated that for all such work only pure aluminium of the best quality should be used, and there is little doubt that naval constructors will find pure aluminium sheets, channels, mouldings, rivets, etc., of great assistance in partitions, ceilings, deck and chart houses, and similar portions of large ships above the water line, where reduction of top weight is of importance in connection with the stability of the vessel. In 1901 a quantity of large aluminium plates were used in the chart house of the s.s. "Celtic," and the owners report that the condition of the material is satisfactory.

Aluminium Tubes.

Large quantities of specially pure aluminium tubes are being used for various purposes in connection with acid work, under which condition the pure metal remains practically unaffected. In order to demonstrate the usefulness of aluminium tubes for steam coils, etc., some tests were made at Milton Works some time ago with the following results:—

Length of tube. in.	Gauge.	O/s diameter in.	Tested to lbs. per sq. in.	Remarks.
12	10	3¼	1,200	Expanded to $\frac{1}{2}$ in. in middle but returned to original size on release of pressure.
12	12	2⅞	1,200	Ditto (barely $\frac{1}{2}$ in.).
12	14	2	1,200	As above, with rather less expansion.
12	14	1¼	1,200	Perfect. Would probably stand considerably more.
12	19	1¼	1,200	Ditto.

All the above were afterwards tested at 100 lbs. per square inch for half an hour, with the exception of the second on the list, which was under the steam test for 12 hours without apparent injury. This tube was, after the steam test, subjected to a second test of 1,200 lbs. hydraulic pressure without showing any signs whatever of fracture.

Electrical Industry.

As a conductor of electric current aluminium has a large and increasing field of usefulness, the difficulties at first met with in regard to jointing, etc., having now been overcome. The saving that can be effected by using aluminium in place of copper for overhead conductors is so large that in countries where long overhead transmission lines are in vogue the lighter metal practically reigns supreme. In this country there has not been up to the present the same opportunities for long distance bare overhead transmission lines, but during the past few years there have been erected many short distance aluminium lines for lighting and power requirements in connection with works, collieries, etc. With the increasing use of electricity for motive power purposes, aluminium conductors are being adopted much more extensively in such directions, engineers and consumers alike appreciating the immense saving in capital outlay secured thereby. Further, at the present low price of aluminium, the saving in cost of the bare conductor is so large that there is an extensive field for the metal for insulated underground cables, even taking into account the increased amount of insulation necessary for the somewhat larger cable.

Aluminium as used for electrical purposes has a conductivity equal to about 61 per cent. of that of pure electrolytic copper, so that to obtain the same conductivity it is necessary to increase the sectional area by 64 per cent. above that of copper, corresponding to an increase in diameter of 28 per cent. for a round conductor. Copper being 3.3 times heavier than aluminium, we see that the somewhat larger aluminium conductor will still weigh less than half of the equivalent copper conductor, the larger cooling surface of the aluminium conductor being a further factor in its favour.

For bus-bars and back connections in switchboards aluminium is also finding an increasing use, the saving in weight allowing of lighter supports and framework, which means additional economy over and above the saving in cost of the conductor. For the front of switchboards, aluminium is also eminently suitable for such fittings as bolts, lamp-holders, instrument cases, etc., the effect against a dark marble board being very pleasing.

There are several satisfactory methods of jointing aluminium conductors, according to the conditions under which it is called upon to work.

For small diameter wires as used for making up into cable the usual butt welded joint is made either in the flame of a blow lamp or by means of the electric welders as used for copper.

For bare stranded cables the usual method is to weld the two ends together by pouring molten aluminium into a cigar-shaped mould previously clamped around the joint, but where high tensile strength is required a mechanical joint may be used, so designed as to give a wedging action when pulling tight in order to ensure good electrical contact.

For insulated underground cables it is not always practical to use welded joints on account of the confined space when working in closed boxes, and in this case either a mechanical or a soldered joint may be used, where the joint is afterwards protected from atmospheric influences. The simplest method is to slip a tube over the two ends of the cable with a slot through which the solder can run. The resistance of such joints is somewhat higher than in the case of welded joints, but they compare very favourably with copper joints made on the same principle.

The tensile strength of hard drawn aluminium wire is equal to about half that of a copper wire of equal section, but allowing for the increased size of an aluminium conductor to obtain the same conductivity as for copper, this figure is raised to about 75 per cent., the difference being more than compensated for by the decreased weight of the aluminium cable.

Alloys of Aluminium.

The alloys of aluminium in common use are confined almost exclusively to combinations of the metal with zinc, copper, and nickel. In general, the proportions of these metals which can with advantage be added to the light metal, do not largely exceed 20 per cent. in the case of zinc, 6 per cent. in the case of copper, and 5 per cent. in the case of nickel. A very interesting and valuable—especially for marine work—series of alloys, known under the name of aluminium bronzes, is also produced by the addition of aluminium in quantities up to 10 per cent. to electrolytic copper.

The Scientific Mixing of Iron for Castings.*

By George Hailstone.

In many foundries it is the custom to purchase a number of different grades of iron by brand and number, regardless of their composition. The reason of this is that different brands possess properties peculiar to themselves; some brands are high in silicon, whilst others contain a large percentage of manganese, and others are high in phosphorus.

This method was probably satisfactory when the irons were made from ores mined and smelted in the same district, which gave rise to the naming of the iron after that district. Thus we have Scotch, Cleveland, Frodingham, Derbyshire, North and South Staffordshire, and Northamptonshire pig-irons, which have had in the past very marked characteristics. Now that most of the local ores in the above districts are almost exhausted, ores have to be obtained elsewhere, and we now find that some brands, which were previously very different, are practically the same as each other. Yet they are mixed in the same

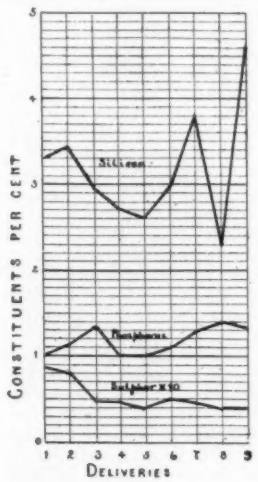


FIG. 1.

proportions as they were years ago, by some foundrymen, with very diverse results. By this method of working, castings of irregular quality are produced; it is very difficult to maintain proper control of the output, because of the great difference in the composition of the iron from day to day, and even in certain parts of the blow, when it has been the intention to make all the castings of a certain grade.

For example, the curve, Fig. 1, shows the partial analysis of a well-known South Staffordshire No. 3 pig-iron, the nine deliveries of which extend over a period of three months. The silicon varies from 2.3 to 4.66 per cent.; the phosphorus from 1.0 to 1.4 per cent.; and the sulphur from 0.040 to 0.085 per cent. It can readily be seen that to use this iron, or any iron satisfactorily, analyses should be taken of every delivery, each delivery being piled in a certain stack according to its composition, and labelled. It may then be mixed and used with certainty.

* Abstract of paper read before the Staffordshire Iron and Steel Institute, Dec. 19, 1908.

Pig-iron should be purchased to specification. There is no difficulty experienced in obtaining a selection of foundry irons which, when mixed in proper proportions, will yield cast iron suitable for any class of castings. Every delivery of each brand of iron should be analysed to check the makers, as they are liable to make very big mistakes at times. For in-

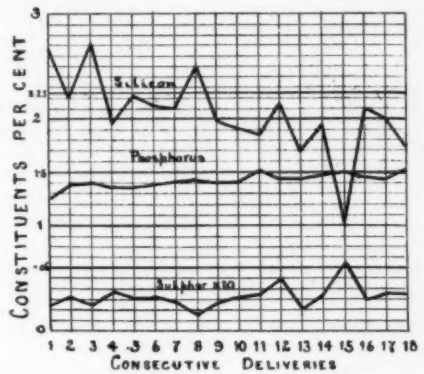


FIG. 2.

stance, the curve, Fig. 2, shows the partial analysis of eighteen deliveries of a well-known brand of Derbyshire pig-iron. The specification for this iron was as follows:—

Silicon	2.0 to 2.25 per cent.
Sulphur not to exceed	0.06 ,, ,,
Phosphorus not to exceed	1.50 ,, ,,

It will be seen that the percentage of silicon is very irregular, rising as high as 2.73 per cent., and falling as low as 1.0 per cent. In only seven out of

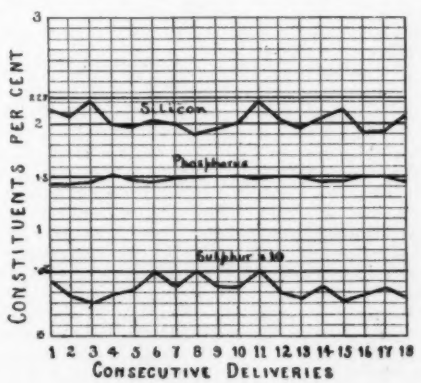


FIG. 3.

the eighteen deliveries does the silicon come within the limits. The sulphur and phosphorus only exceed the maximum once in each case. In using this iron, to rely on the makers' analysis showing between 2.0 and 2.2 per cent. of silicon would be to land into difficulties.

It may be said that this is as near as the blast furnace can be worked, but the curve Fig. 3 shows the partial analysis of another brand of iron made to the same specification, and in the same district as the one preceding. In this case it will be seen that in twelve deliveries the silicon is within the limits; also that it is not more than 0.1 per cent. out in any of the others. The phosphorus only just exceeds the maximum in one case, the sulphur not exceeding the limit at all. This curve shows what can be done at the blast furnaces.

Every consignment of pig-iron that goes into a foundry should be sampled and analysed. In a paper read before the Birmingham Metallurgical Society on "The Sampling of Pig-iron," I fully dealt with the best method of sampling and drilling pig-iron for analysis. (See FOUNDRY TRADE JOURNAL, July, 1908.) The following is the method adopted (it also may be added that this method has proved itself most most satisfactory, both when a quantity of iron has been re-sampled and re-analysed; also, which is of the greatest importance, that analyses of the resulting irons made from mixtures of iron mixed by the aid of the analyses of samples taken this way, agree absolutely with the calculated analysis of the mixtures).

From every five tons, or part of five tons, of pig-iron in a consignment, one pig is taken. When a consignment is of five tons or less, two pigs are taken to make certain an average sample has been obtained. Each pig of iron is broken into three parts, one part consisting of the sample. Thus, from a consignment of twenty-seven tons of iron, the samples would consist of six pieces of pig-iron. The samples of pig-iron are well brushed with a strong wire brush, to remove any adhering particles of sand. The outside skin on the top and bottom of the samples is removed either by machining or grinding off. Each pig is then drilled through from the top side to the bottom side by means of a half-inch twist drill. The drillings from the various pigs that form the samples are then mixed well together. A smaller sample is then obtained, which is ground up fine by means of an agate mortar and pestle. The sample is then ready for analysis.

When the chemical composition of the pig-iron has been obtained, the iron should, as before stated, be stacked and numbered according to its analysis.

Scrap.

The tendency of graphite to form when cast iron is cooling makes thin castings soft, otherwise they may be too hard to machine. The re-melting of pig or cast iron tends to reduce the graphitic carbon by the increase and decrease of the other metalloids present in the iron. Scrap, being re-melted pig-iron, is profitably employed in mixtures for castings which are thick and heavy, in order to close up the grain of the iron and make it solid and strong, even where it is thick in section. It will be seen that scrap should be used more carefully and sparingly in mixtures for thin castings, and freely and in considerable quantity in large and heavy castings, the only danger being that every time the iron is melted it increases in its sulphur content. Much scrap of unknown quality must never be used, as it is liable to carry a high percentage of sulphur. Apart from cheapening the mixture, scrap iron should be used to improve the quality of the iron produced. If the improvement in quality be kept in view, it will lead to the rejection of any pieces which are unfit to use, such as burned iron found in old annealing boxes, fire-bars, and similar materials. The scrap iron made in a foundry, such as gates, risers, wasters, etc., is readily classified, being similar in composition to the castings produced.

Purchased scrap is always doubtful in character. It is always necessary to take a good average sample from each delivery of scrap iron, analyse the sample, and use it in the mixture according to that analysis. I find that by selecting about twelve pieces of scrap from a delivery of ten tons, taking equal amounts of drillings from each, well mixing, and then obtaining the analysis of the mixture, a satisfactory average analysis of the whole ten tons is obtained, which works out well in the mixture.

Coke.

All coke coming into the foundry should be analysed. Good foundry coke should contain not more than 8 per cent. of ash, nor more than 0.75 per cent. of sulphur. On no account should coke be used containing less than 88 per cent. of fixed carbon.

The following information and analyses will serve to illustrate what a first-class foundry coke is:—

	Lancashire Coke. Per cent.	South Wales Coke. Per cent.	Pitch Coke. Per cent.
Ash	6.530	5.760	1.109
Sulphur	0.584	0.618	0.548
Volatile matter	0.321	0.458	1.249
Fixed carbon	92.565	93.164	97.094
Specific gravity	1.827	1.760	1.540
Volume of pore space	40.00	49.80	34.19
,, solid substance	60.00	50.20	65.81
Appearance of coke ...	Grey with medium sized pores.	Grey with very small pores.	Black with large pores.

It is very interesting to note that the coke manufactured from pitch only contains 1.109 per cent. of ash. Also the specific gravity of this coke is less than the other cokes, but as this coke contains a bigger volume of solid material in a given amount it is heavier, bulk for bulk, than the other cokes. This coke is harder than the general run of foundry cokes, also it does not crush or break up in the cupola. Some people suppose that coke containing only a small percentage of ash cannot be made hard and dense enough for good work in the cupola, but this case proves it is not so.

The pitch coke is very useful when exceedingly hot iron is to be obtained. When abnormally low total carbon irons are being melted in the cupola, on using the pitch coke in equal proportions with an ordinary foundry coke, the carbon in the iron tapped from the cupola is found to be normal, also there is no reduction in the temperature of the molten iron such as is noticed when abnormally low total carbon irons are melted with the same quantity of ordinary foundry coke.

I have seen it stated that foundry coke should sink when thrown on to water. When considering the question of the use of coke in a cupola, it should be remembered that it is more a question of volume than of weight. The action of melting takes place at a point from 18 in. to 2 ft. above the topmost tuyere, and the amount of coke that is required to ensure successful working is such that will maintain this level.

Limestone.

Limestone is used in the cupola, in amount from 20 to 80 lbs. per ton of iron melted. The amount of limestone required to produce a fluid slag depends upon the quality of the limestone, the amount of ash in the coke, and the condition of the iron to be melted.

The limestone used for fluxing in a cupola should be as pure as it is possible to obtain. It should on no account contain more than 2 per cent. of silica, and not less than 53 per cent. of lime. With limestone containing 3 per cent. of silica difficulty will be experienced in keeping the slag notch of the cupola open, also dull iron will be melted unless a large excess of limestone be used, which will require more coke to melt the extra slag formed. The following

two analyses are of samples of Derbyshire limestone which have been found to work very well in practice: —

	(1)	(2)
Calcium oxide ...	55.980 per cent.	56.000 per cent.
Carbon di-oxide ..	43.520 ,,	43.735 ,,
Silica	0.240 ,,	0.097 ,,
Phosphoric acid ...	0.001 ,,	0.015 ,,
Sulphuric acid ...	0.012 ,,	0.153 ,,
Ferric oxide ...	0.290 ,,	None ,,

Composition of Iron Mixtures.

The composition of the iron to be used for making a casting depends upon the size of that casting; that is. its thickness as affecting its rate of cooling. It is impossible to find any one mixture that is suitable for heavy and light work. The mixture of irons used to make large castings close, solid and strong, would make a small thin casting hard, flinty, and impossible to machine. If only light castings are to be produced, mixtures that are low in sulphur, fairly high in phosphorus, and high in silicon should be used. These elements give softness, and at the same time sufficient strength for ordinary purposes. Supposing large and heavy work is to be made, where soundness and strength is most essential, the iron to be poured into those castings must be harder, and is produced by using irons fairly low in silicon, lower in phosphorus, but there may be considerably more sulphur than could be allowed in light castings.

The calculation of a mixture of cast iron is simply a question of elementary arithmetic, which is dependent upon the following data being known: —(1) The analysis of the pig-iron and scrap available; (2) the changes that take place in melting; (3) the composition of the metal required.

The influence of any one pig-iron in a mixture with regard to any one element in that pig-iron is proportional to the weight of that pig-iron in the mixture, and to the percentage of the particular element it contains. The combined influence is obtained by multiplying the weight of the pig-iron by the percentage of the element.

Changes During Melting.

The changes that take place in the melting of cast iron in the cupola depend upon various conditions, among which are: —(1) The construction of the cupola; (2) the pressure and volume of blast; (3) composition of coke used; (4) grade of iron being melted. Every foundryman must obtain his losses and gains in melting cast iron under his own conditions of working.

In melting ordinary grey iron, containing 2.0 per cent. and upwards of silicon, as a rule there is a loss of from 0.2 to 0.3 of 1 per cent. of silicon. When the iron contains less than 2 per cent. of silicon the loss decreases, and with 1.5 per cent. of silicon there is practically no loss.

Unless the total carbon is abnormally high there is practically no change in the percentage, but with a high blast pressure graphitic carbon is reduced 0.1 or 0.2 per cent. If the total carbon is abnormally low, it will tend to increase to its normal amount by robbing the coke of some of its carbon. Manganese tends to decrease in quantity. An iron containing 1 per cent. of manganese and a normal amount of sulphur loses from 0.2 to 0.3 of 1 per cent., an iron containing about 0.7 per cent. of manganese will lose about 0.1 of 1 per cent., and an iron containing 0.3 per cent. of manganese will practically lose nothing. Again, if the sulphur in the iron is abnormally high, a greater loss of manganese is noticed, due to the formation of manganese sulphide which is slagged off.

There is practically no loss or gain on the phosphorus. The increase in the percentage of sulphur is generally from 0.2 to 0.38 of 1 per cent., excepting when a very pure coke is used, or the mixture contains a large percentage of manganese, when I have found, under certain conditions, the percentage of sulphur has actually decreased.

An actual example of the kind of test required to be made to find out the changes that occur in melting iron in a cupola for the production of light castings is shown below. The analyses of each brand of iron and of the scrap to be used in the mixture were obtained. The calculated analysis of the certain mixture of the different irons was obtained by a method that will be explained later.

Brand of Iron. Stack No.	Cwts used.	Si. per cent.	Si. cwts. per cent.	S. per cent.	S. cwts. per cent.	P. per cent.	P. cwts. per cent.	Mn. per cent.	Mn. cwts. per cent.
No. 20	2	3.970	7.940	0.058	0.116	0.383	0.766	0.732	1.464
No. 31	3	3.904	10.512	0.007	0.021	1.204	3 612	0.534	1.602
No. 25	1	3.082	3 082	0.069	0 069	0.993	0.993	0.621	0.621
No. 17	2	2.000	4.000	0.045	0 090	1.504	3.008	0.485	0 970
Scrap	2	2.000	4.000	0.100	0.200	1.100	2.200	0.156	0 912
Total	10		29 534		0.496		10.579		5.569

Thus on a 10-cwt. charge the calculated analysis of the mixture is: —Si., 2.953 per cent.; S., 0,049 per cent.; P., 1.057 per cent.; Mn., 0.556 per cent. The mean of the actual analyses of the mixture on six consecutive days showed, Si. 2.704, S. 0.0875, P. 1.053, Mn. 0.4555. This equals loss of Si. 0.249, gain of S. 0.0379, loss of Mn. 0.101

The phosphorus was practically the same as in the calculated mixture.

The Calculation of Mixtures.

In the first case let us take one of the most simple forms of calculation, in which the weights of the different irons that make up the charge are known and the percentage of any one element, say silicon, is required.

For example, let us take, say, 3 cwts. of Priorfield pig-iron containing 4.0 per cent. of silicon, 4 cwts. of Diamond all-mine pig-iron containing 2.25 per cent. of silicon, and 3 cwts. of scrap, containing 2.0 per cent. of silicon. The weight of pig-iron and scrap used is multiplied by the percentage of silicon each contains. The sum of these numbers gives the total cwts. per cent. of silicon in the charge. This result, divided by the total weight of the charge, gives the percentage of silicon in the calculated mixture, thus: —

Brand of Iron.	Cwts. used.		Silicon per cent.		Silicon cwts. per cent.
Priorfield ...	3	×	4.00	=	12
Diamond all-mine	4	×	2.25	=	9
Scrap	3	×	2.00	=	6
	10	×	Per cent. of Si. in mixture.	=	27

Then $\frac{27 \text{ cwts. per cent. of Silicon}}{10 \text{ cwts.}} = 2.7$ per cent. of Silicon.

=2.7—loss of Silicon in melting= per cent. of Silicon in casting.

=2.7 − 0.249=2.451 per cent. of Silicon in casting.

Let us now suppose the compositions of the pig-irons and scrap available are given, and metal of a specified composition is required. For example, it is required to make an iron containing 2.451 per cent. of silicon in the finished casting. This percentage, plus 0.249, which is the loss of silicon in the cupola, gives 2.7 per cent. of silicon to be in the calculated mixture. Take the same irons as before, study their analyses, not as to their actual content of silicon, but as to their relative positions to the amount of silicon required in the mixture. For the sake of simplicity I will eliminate the scrap iron containing 2.0 per cent. of silicon from the mixture. We now find that the weight of the Priorfield pig-

iron multiplied by its height in silicon above the Diamond pig-iron, must equal the weight of the mixture multiplied by its height in silicon above the Diamond pig-iron.

Thus the Diamond pig-iron containing 2.25 per cent. of silicon is the lowest, and the Priorfield pig-iron containing 4 per cent. of silicon is 1.75 above it, and 2.7 per cent., the amount of silicon required in the mixture, is 0.45 above the Diamond pig-iron in silicon.

In calculating a charge of 10 cwts., the procedure is as follows:—Weight of the 4 per cent. silicon iron $\times 1.75 = 10$ cwts. $\times 0.45 = 4.5$. And the weight of the 4 per cent. silicon iron $= \frac{4.5}{1.75} = 2.57$ cwts.

The weight of the iron containing 2.25 per cent. of silicon required is 10 cwts.—2.57 cwts., or 7.43 cwts.

On checking this charge as in the first example we obtain:—

Brand.	Cwts. used.		Si. per cent.		Si. cwts. per cent.
Priorfield ...	2.57	×	4.00	=	10.28
Diamond ...	7.43	×	2.25	=	16.72 nearly.
	10.00	×	per cent. of Silicon in mixture.	=	27.00

This is equivalent to 2.7 per cent. of Si. in the charge, which, after deducting 0.249 loss in melting, gives 2.451 per cent. of Si. in the casting.

Further, suppose that 30 per cent. of scrap containing 2.0 per cent. of silicon must be used in a 10-cwt. charge. Ten cwts. at 2.7 per cent. of silicon will require 27 cwts. per cent. of silicon in the mixture, but 3 cwts. of scrap at 2.0 per cent. silicon will add 6.0 cwts. per cent. of silicon, leaving 27—6, or 21 cwts. per cent. to be found in the remaining 7 cwts. of the charge, an average of $\frac{21}{7} = 3$ per cent.

The lowest of the three irons remaining is the Diamond pig-iron containing 2.25 per cent. of silicon, and the other, the Priorfield, containing 4.0 per cent. of silicon, is 1.75 above it in silicon, whilst 3 per cent., the amount to be aimed at, with regard to the two pig-irons, is 0.75 in silicon above the Diamond iron containing 2.25 per cent. of silicon.

Thus the following equation:—Cwts. of Priorfield pig-iron $\times 1.75 = 7$ cwts. $\times 0.75 = 5.25$.

$\frac{5.25}{1.75} = 3$ cwts. of Priorfield iron at 4 per cent. of silicon and 7 cwts.—3 cwts. = 4 cwts. of Diamond all-mine at 2.25 per cent. silicon.

On checking this charge as before we get the following:—

Brand.	Cwts. used.		Si. per cent.		Si. cwts. per cent.
Priorfield ...	3	×	4.0	=	12
Diamond ...	4	×	2.25	=	9
Scrap ...	3	×	2.0	=	6
	10				27

This gives the same per cent. of silicon in the casting.

The foregoing examples show all that is necessary in making up any mixture of iron for castings. I will now take an actual example of the first type. The analyses and percentages of the irons to be used in the mixture are known, the composition of the resulting metal is to be obtained. The percentages of the different irons to be used in the mixture are:—

Pig-iron No. 22, 10 per cent.; No. 26, 20 per cent.; No. 38, 10 per cent.; No. 40, 10 per cent.; scrap, 50 per cent.

The analyses of these irons are:—

	Constituents per cent.		
Pig iron.	Silicon.	Sulphur.	Phosphorus.	Manganese.
No. 22 ...	2.80	0.07	1.25	0.46
,, 26 ...	2.20	0.03	1.46	0.48
,, 38 ...	3.70	0.04	1.10	0.52
,, 40 ...	3.09	0.05	0.80	0.66
Scrap ...	2.00	0.10	1.10	0.45

The following shows how the mixture should be tabulated and the calculated composition obtained:—

Iron.	Cwts. used	Si. per cent.	Si. cwts. per cent.	S. per cent.	S. cwts. per cent.	P. per cent.	P. cwts. per cent.	Mn. per cent.	Mn. cwts per cent.
No. 22	1	2.80	2.80	0.07	0.07	1.25	1.25	0.46	0.46
No. 26	2	2.20	4.40	0.03	0.06	1.46	2.92	0.48	0.96
No. 38	1	3.70	3.70	0.04	0.04	1.10	1.10	0.52	0.52
No. 40	1	3.09	3.09	0.05	0.05	0.80	0.80	0.66	0.66
Scrap	5	2.00	10.00	0.10	0.50	1.10	5.50	0.45	2.25
Total	10		23.99		0.72		11.57		4.85

By tabulating the irons as shown, and multiplying the percentages of the different elements in the different irons by the cwts. of the irons to be used, and adding up the totals obtained of the same elements in the different irons, we obtain the cwts. per cent. of each element in the mixture. As it is a 10-cwt. charge that has been calculated, the cwts. per cent. of each element divided by 10 will give the calculated composition of the mixture. Thus this mixture will contain:—Silicon, 2.399 per cent.; sulphur, 0.072 per cent.; phosphorus, 1.157 per cent.; manganese, 0.485 per cent.

The mixture, on being melted in the cupola, will, as before shown, undergo various changes, so that to obtain the calculated composition of the iron that will form the casting, 0.249 per cent. must be deducted from the silicon; 0.0379 per cent. must be added on to the percentage of the sulphur; the phosphorus remains unaltered; and 0.101 per cent. must be deducted from the percentage of the manganese.

Thus we find:—

	Calculated analysis. Before melting.		After melting.
Silicon	2.399 — 0.249	=	2.150
Sulphur	0.072 + 0.037	=	0.109
Phosphorus	1.157	=	1.157
Manganese	0.485 — 0.101	=	0.384

I have used this form of calculation with great success. Any mixture may be calculated this way; the composition of the resulting castings and of the available irons are all that are needed. The irons are then sorted out as to their relative compositions, tabulated as shown, and different amounts of each tried until the proper proportion is arrived at.

Let us suppose a mixture is required to the following specification:—

	Per cent.
Silicon	2.00 to 2.10
Sulphur	0.10 to 0.11
Phosphorus	1.10 to 1.20

After making due allowances for the reduction of 0.249 in the silicon and an increase of 0.0379 in the sulphur, the mixture to be calculated must consist of the following (the composition aimed at being the mean of the two extremes of the specification):—Silicon, 2.300 per cent.; sulphur, 0.067 per cent.; phosphorus, 1.150 per cent.

Suppose we have only the following three irons and scrap available to make up this mixture, the analyses of which are:—

	Silicon.	Sulphur.	Phosphorus.
Pig-iron No. 42	2.0	0.045	1.5
Pig-iron No. 45	5.0	0.005	1.1
Pig-iron No. 46	2.0	0.045	0.5
Scrap	2.0	0.0.0	1.2

It is also necessary for us to use in this mixture 70 per cent. of scrap, and equal parts of Nos. 42 and

45 pig-irons, as we are limited to the cost of same, and we are bound to produce the mixture at the lowest possible figure.

By using equal parts of the No. 42 and the No. 45 pig-irons, one of the irons is cut out of the calculation. By taking the mean analysis of the No. 42 and No. 45 pig-irons an iron of the following analysis is obtained:—Silicon, 3.500 per cent.; sulphur, 0.025 per cent.; phosphorus, 1.300 per cent.

It now remains to be found what amount of the mixture of equal parts of Nos. 42 and 45 pig-irons and the No. 46 pig-iron has to be used.

Calculating as before on a 10-cwt. charge, it will be seen that 10 cwts. at 2.3 per cent. silicon will require 23 cwts. per cent. of silicon, but 7 cwts. of scrap at 2.0 per cent. silicon will add 14 cwts. per cent. of silicon, leaving $23-14=9$ cwts. per cent. of silicon to be added by the 3 cwts. of the mixed pig-irons. This gives 3 per cent. of silicon to be produced by the mixed pig-irons.

In working out the amounts to obtain the required silicon it is noticed that the pig-iron No. 46 contains 2.0 per cent. of silicon, also that the mixture of equal parts of Nos. 42 and 45 pig-irons containing 3.5 per cent. of silicon is 1.5 per cent. above the No. 46 pig-iron in silicon, whilst 3.0 per cent., the amount required, is 1.0 per cent. above the pig-iron No. 46 in silicon.

Therefore the cwts. of pig-irons Nos. 42 and $45 \times 1.5=3$ cwts. $\times 1=3$ cwts. and $\frac{3}{1.5}=2$ cwts.

Two cwts. of equal parts of pig-irons Nos. 42 and 45 leaves 1 cwt. of No. 46 pig-iron to be used in the mixture. To obtain 2.3 per cent. of silicon in the mixture the following quantities of the different irons will have to be used:—No. 42, 1 cwt.; No. 45, 1 cwt.; No. 46, 1 cwt.; scrap, 7 cwts.; total 10 cwts.

By the same method the phosphorus is determined. Ten cwts. at 1.15 per cent. of phosphorus will require 11.5 cwts. per cent. of phosphorus.

In the foregoing mixture the irons were found to fall in well one with another to produce the required analysis; sometimes they do not. In the latter case, all that is necessary is to blend two or three irons together, in certain proportions, as in the case of the pig-irons Nos. 42 and 45, to produce an iron of an analysis which will perhaps fit in.

The curve Fig. 4 shows sixteen consecutive analyses of a mixture, the specification of which was:—

	Per cent.
Silicon	2.0 to 2.2
Sulphur	0.09 to 0.11
Phosphorus	1.10 to 1.20

The tests extended over a period of about four months, nine different mixtures of different irons being used during that period to produce iron to the above specification. I think this curve will show how very near a specification can be worked to in actual foundry practice, over an extended period, also how a high standard of efficiency can be attained.

The fuel ratio and size of each charge of fuel and iron in any one cupola can only be obtained by actual experiment with that cupola. There are many managers of foundries who think fuel placed in a cupola melts iron no matter how it is put in. In such cases an excess of fuel is nearly always used, the melting is slow, and the amount of iron charged is often more than required, or it is insufficient, and more has to be charged after the charges are low in the cupola, which means still more fuel being used and undue wear on the furnace lining.

When iron is run from the cupola into the ladle, when the furnace is working properly, the iron is white hot. Sometimes it requires a number of tappings to fill the ladle; in this case care must be taken to prevent the iron from cooling. For this purpose ground coke may be thrown on to the surface of the metal.

Allowing the iron to stand in the ladle has a good effect upon its character, providing it is not allowed to get too cold. The absorbed gases are given time to escape, the manganese and silicon present in the iron act upon the dissolved and mechanically mixed oxides present and decompose them, forming manganese silicate which passes into the slag. The manganese also has time to assist in the elimination of the sulphur present by the formation of manganese sulphide. This manganese sulphide rises to the surface of the metal and passes into the slag; the hotter the metal the more perfect these reactions are.

Sometimes additions of some foreign material are made to the metal in the ladle to eliminate the dissolved gases, etc., but by using proper mixtures, and working the cupola to its best advantage, these are

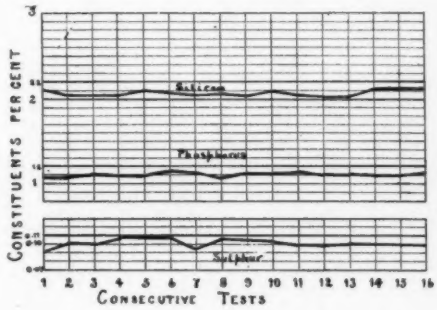


FIG. 4

not necessary. The materials added to molten iron may be divided into two classes, those acting mechanically and those acting chemically. To the first type belong such additions as lead, zinc, and tin. These are added in the proportion of from one to two ounces per ton of metal. They boil away at the temperature of the molten metal, and so agitate it as to cause the gases and mechanically mixed impurities to rise to the surface. Stirring the metal before pouring or poling with a stick of wood have, however, the same effect. The metals mentioned above will not reduce oxides. To the second group belong such metals as aluminium, sodium, magnesium, and titanium. Sodium and magnesium are at present, I think, very rarely used, though they are probably present in some of the alloys now sold. The addition of aluminium to cast iron is more general. It is added either as pure aluminium, ferro-aluminium, or thermit, in quantity amounting from 0.02 to 0.05 per cent. of the weight of the iron to which it is added. The use of aluminium is limited to iron fairly high in silicon. With low-silicon irons it cannot be used, because it readily promotes the formation of graphite, which is very undesirable in low-silicon irons for strong castings. The addition of 0.2 per cent. of titanium to a low-silicon iron, all the titanium being oxidised, is claimed to strengthen that iron 20 per cent.

When iron is about to be poured the surface should be scraped clean and some dry moulding sand thrown on the clean surface. This produces a thin coherent slag, which protects the metal from further oxidation during the casting process, whilst it is prevented from passing forward with the iron.

The Casting of Turbines.

By J. H.

The turbine marine engine may be safely said to have come to stay, and ironfounders are required to turn their attention to the production of suitable castings for the manufacture of turbines—castings which will stand the highest possible test, and have also a certain amount of pliability in order to obviate cracking in case of the sudden cooling of any particular part. Various methods have been tried for producing good castings of the desired pliability, able to stand the test required, and the ironfounder has, for this purpose, had to add a certain amount of low-carbon steel to his metal mixture. Briefly, a turbine is like a large cylinder cut in halves longitudinally, in lengths of 6 ft. to about 18 ft. A flange is made around each half at the bottom and ends so that each half can be bolted together, thus forming a large pipe on which at different points there are various pockets and valve seats. There are also strengthening brackets of various designs on the outside.

When first taking up turbine work I found that other founders were casting the plain side down, which necessitated a large amount of tackle. Amongst the tackle used was the following:—For the core: A large bottom plate with eight large staples cast in, also two large bars to go through the staples and overlapping the end of the core about 18 in., the spare end of the bar being used for lifting the core with; the whole of the plant for the core alone would weigh over six tons, and in addition was to be considered the making of the eight staples, which were of 3-in. square iron. For the mould there were two drawback plates cast, one for each side, each weighing over four tons, and again the heavy staples were in evidence to the number of six, three in each plate. These staples were used for lifting purposes. In each plate were cast four pieces of 1½-in. iron, the depth of the drawback, also two pieces the same thickness at each end. A back plate and two end plates were then cast, these plates resting on the bottom plate and standing perpendicularly against the 1½-in. irons cast in the plate. The whole formed a large drawback up to about three parts of the height of the casting, which was then rammed up, the top joint made, and the top rammed. The casting, roughly speaking, would be about 15 ft. long by 20 ft. broad, the whole surface making an area of about 300 square feet. It is hard to realise the enormous lift there would be on the whole of the top, and the tremendous pressure on the bottom. To keep the whole lot down it was necessary to cast four large bars weighing perhaps from seven to eight tons each. These were placed in position and the top bolted down with them. The whole of the plant required to cast them in a flat position, would weigh something like 25 tons, apart from the heavy bars to keep the top down; and then after casting there would only be about half the plant of any further use.

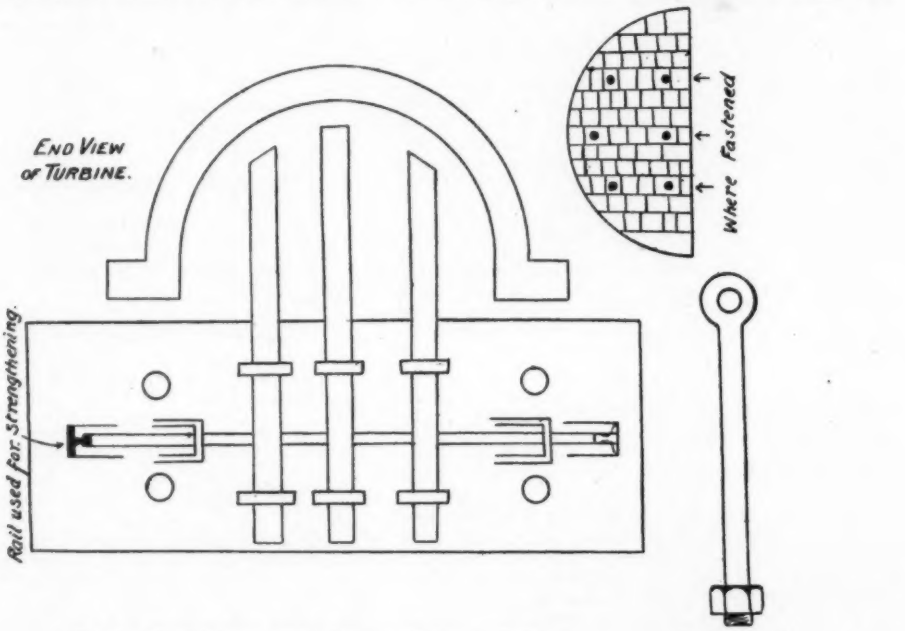


FIG. 1.—CORE PLANT WITH LIFTING HOLES AND BARS IN POSITION.

BOLT USED FOR LIFTING.

On examining a bad casting which had been returned because it would not stand the test, I found that in the thickest parts of the casting, where the brackets were, there was a large number of rough holes with a thickness of metal over them, varying

from 1 in. upwards. I noticed in particular that the holes were only on the top part of the casting, and on enquiring whether there was any steel in the metal was informed that there was. I attributed the defect to an excessive amount of steel used, and taking into consideration the position the job had been cast in, concluded there was not enough pressure on the top to stop the segregation of the steel, subsequent events proving that this conclusion was right. It would pay engineering firms to have a foundry expert in their employ to determine in what position a casting ought to be cast; he would also be able to advise in the making of the pattern.

After careful consideration I decided to cast such a job end up. I had to instal a new casing 25 ft. deep, 25 ft. wide, and 30 ft. long. It was then rammed up as far as was required, and a level bed made for the pattern to rest on. The pattern was kept down 4 ft. from the level of the top of the casing for reasons explained later. The pattern was then placed in position, weighted down, and the core side stayed from the side of the casing. The moulders then commenced to ram the outside up, releasing all the brackets by taking out the screws from the core side. The facing sand used was the strongest clayey Erith sand, thoroughly milled. The sand was placed about 3 in. thick next to the pattern and rammed hard. When the whole of the outside had been rammed up, I had a skeleton pattern ready, 4 ft. high, the same diameter as the outside of the body of the turbine (not the flanges). This was placed in position on the top of the pattern in a direct line with the body of the casting; it was then stayed and weighted down, and rammed level with the top of the case. The skeleton frame had pieces of flat wood about 2 ft. long placed close together sideways, and being level with the joint, enabled the moulder to ram 18 in. over the edge of the pattern on the core side. The top box was then put on; flat gates, twelve in number, were placed around the job on the top, the size of the gates being 3 in. wide at the bottom, 3½ in. at the top, ¾ in. thick at the bottom, and 1 in. at the top. There were also two large risers at each end of the casting, well clear of the runners. After the top had been lifted off it was finished and blacked from underneath; the gate sticks were placed in their position again, and a layer of soft loam, 1 in. thick and 2 ft. broad, was placed on the top and allowed to stiffen. The gates were then withdrawn, and tapered blocks, 6 in. square, placed so as to cover all the gates. They were then built round with bricks, a level joint being made at the top. A plate was cast, to cover the whole of the runner, the plate having two 6-in. holes cast in; it was then bedded on to an inch of loam over the runner, allowed to stiffen, and lifted off. The channel blocks were then drawn out, the runners all shaped up, dried and blacked, thus forming a channel 6 in. square connecting the whole of the 12 gates together.

We now commenced with the mould. The skeleton pattern on the top was drawn out first, leaving a blank wall 4 ft. above the top of the casting, which, when the core was placed in position, constituted a 4-ft. head, the casting really being 4 ft. longer. The pattern was then drawn in over, leaving the whole of the face of the mould bare. The moulders started at the top, finishing and drawing the brackets out till they got to the bottom; the mould was then blacked, given one night's firing, washed over with plumbago, and given another 24 hours' firing.

We will now consider the core. A plate was cast 20 ft. long, 6 ft. wide, with four 3½-in. holes cast in, two at each end, and 2 ft. from the end of the plate. The plate weighed six tons. Four 3-in. bolts went through the holes, and the nuts were screwed on from the bottom. There were also six 2-in. square iron staples cast in the centre of the plate, the staples being of a size to allow a 6-in. metal bar to go through; the metal bars were 12 ft. long. (I may state that the plate and bars have been used for all the turbines that we have cast, and when the diameter of the casting was smaller, we loosened the bars, drew them in and re-fastened them.) The plate was then laid on pieces of packing, just enough to clear the nuts on the bottom of the plate, and a bearance made for the outstanding part of the core. The three strong bars were placed to suit the diameter; a strong grate was cast and bedded on to 2 in. of loam, then strongly bolted to the three bars, the grate being cast so as to allow 2 in. clearance all round. The core was then built up with loam and bricks with the necessary binders. When the core box was at liberty, it was used again to make a piece 4 ft. high, which fitted on to the top of the fore when the core was placed in its position in the mould, thus forming the other part of the head on top of the casting. After both cores were dried they were placed together, rubbed and straight-edged up. The only plant that has to be recast are the grates and binders for the core and the top channel plate for the runner, and these only in case of breakage or a difference in diameter.

We then commenced to close the mould; the fires were lifted out and the mould thoroughly cleaned out. The cores were placed in position, and the open spaces left at the back and sides were well rammed up, the bottom plate and binders being stayed from the side of the casing. After the back had been rammed up level the top was put on and bolted down to the casing. A strong bar was placed across the box and the centre of the box was stayed from it; the channel plate on the top of the runner also was stayed from the same bar. Two metal runners, 15 in. deep by 12 in. wide, were then placed in position. These were cast in open sand, with a 1-in. ledge on the bottom all round, which allowed of a ½-in. plate resting on to form the bottom of the runner, where the metal was poured in it was 3 ft. square. The whole runner box was then daubed thinly with loam, dried and blacked, the narrow end being left open about 1 ft. The reason for this was that when the runners were finally placed, a 6-in. plug or gate stick was placed in the large holes in the channel plate, and then rammed up level with the bottom of the runner with milled sand, blacked and dried.

The runners were placed on opposite sides to each other, and the pouring was done from two 12-ton ladles. The casting was fed with the two large flows at each side. The mixture employed was 1 ton of Port Clarence pig-iron, 5 cwts. of picked scrap, and 1½ cwts. of soft steel. I have found that cuttings of steel shipbuilding plates are most suitable, as they are of a uniform nature.

A week or so after the casting was despatched the 4-ft. head was sent back, and the weight allowed for. On examination, this piece disclosed the hollow places I had noticed in the condemned casting mentioned previously, but not in so marked a degree, the holes not being so large. All of the returned heads had the same defect; the nearest holes were 9 in. from the top of the casting. I have cast hundreds of castings with heads ranging from 1 to 4 ft., but they have never exhibited the same defects as the turbine heads with the steel mixture.

Messrs. J. Younger and M. E. Gallon, Dunston-on-Tyne, Durham, iron and brass founders, who traded under the style of Younger & Gallon, notify a dissolution of partnership.

New Power Moulding Machine for Small Work.

The accompanying illustrations show a new power moulding machine, one of the principal features of which is the method adopted to secure power ramming of the mould. The power is, in fact, this lever is moved the rammer rises and falls continuously at the rate of about thirty blows to the minute, and may be instantly stopped. The ramming of moulds of different depths and the charging from

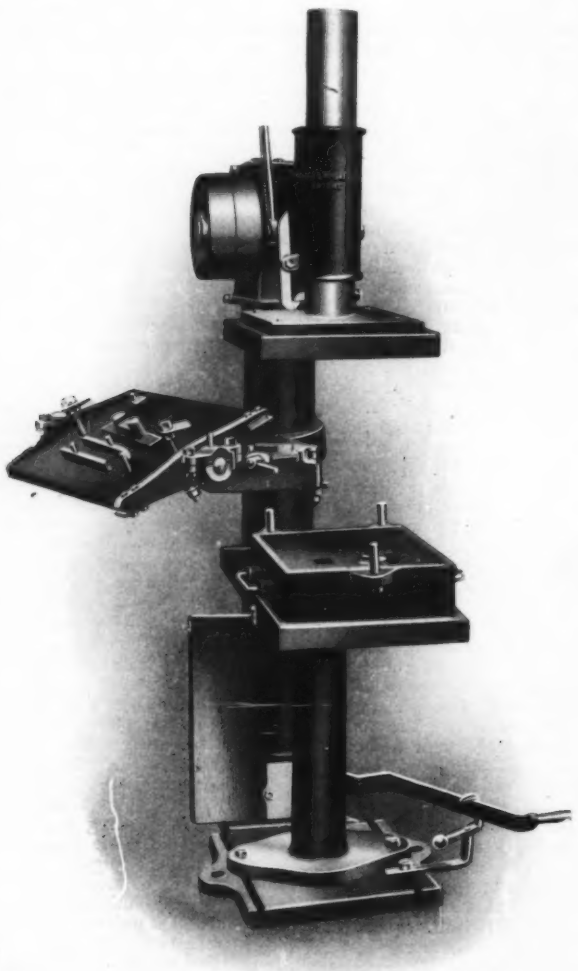


FIG. 1.—GENERAL VIEW OF THE EVANS-MCGREGOR MOULDING MACHINE.

in use only when lifting the rammer from the mould to its highest position, where it is automatically released and drops free on to the sand, the weight of the rammer being quite sufficient to ram the mould. Any number of blows may be given to suit moulds of different depths, as when the starting lever is moved the rammer drops, and is raised by the action of a chain attached to its base, and connected by means of a clutch to the driving pulley. When once shallow to deep boxes and patterns does not call for any special adjustment, the machine ramming moulds 2 in. deep and 6 in. deep equally well. It is simply a matter of more blows being required for the deeper moulds, and the exact number required is easily ascertained by trial.

This machine is designed for small work only. The power required is about ½ h.p., and the driving may be by belt, or by an electric motor attached to a

bracket at the top of the machine. All working parts are shielded from dust and sand, being completely enclosed, and above the floor.

Description of Machine.

The illustration (Fig. 2) shows a side elevation. A is a baseplate, on which is bolted the column B and

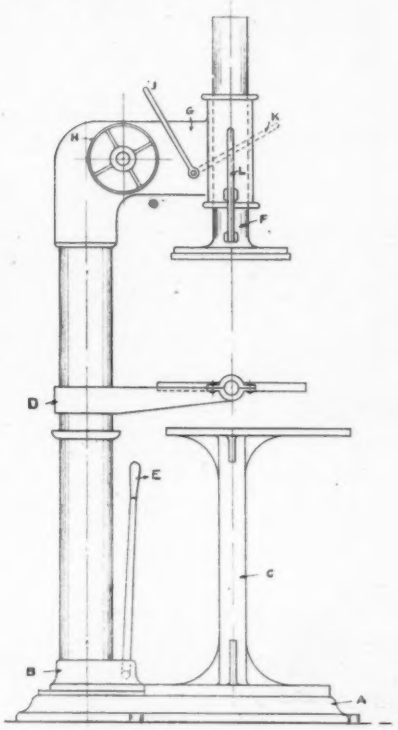


FIG. 2.—THE EVANS-McGREGOR MOULDING MACHINE.

the table C. The top of the table is machined, and will be found very useful for the ramming up of "flat backs." D is a plate pattern-carrier and drawing device, which is raised or depressed by the lever E. D is also provided with swivels in which a machined plate revolves, so that the patterns are fixed on either side of the plate and rammed. Provision is also made for holding the moulding box to the plate when it is being turned over. The carrier D can be swung round on the column B, so that moulds may be rammed direct on the table C, as in the case of loose patterns. F is the ram. G is a chambered casting attached to the top of the column and carrying the ram and driving mechanism, securely protected from injury and dirt. H is the driving pulley, and I the starting lever. When the lever I is brought over to the position indicated by the dotted lines K, the catch L is released, and the rammer drops, then continues to rise and drop until the lever is put back again to I. There is no strain whatever on the chambered casting when the rammer is working, as it simply drops on to the sand as before mentioned.

Range of Usefulness.

This little machine is suitable for any number of small repetition castings. The full action of the machine is to ram the mould, fasten the moulding-box to the plate, turn it over, and draw the pattern. When loose patterns are being worked the plate carrier is swung out of the way and the pattern worked on the table, which is used as a moulders' bench. The rammer rams loose patterns equally as well as hand-ramming and in much less time than is required by the latter process. Flat top parts are rammed direct on the table, and stripping-plate work is readily rammed by removing the table C and placing the stripping-plate machine under the rammer.

The labour employed (when the machine is fully mounted with patterns on each side of the plate) need not be skilled. Two youths of 18 can, it is claimed, place a complete mould, consisting of two parts 12 in. by 10 in. and 3 in. deep, on the floor every two minutes, or, allowing a margin for contingencies, twenty-five moulds per hour.

The machine is the patent of Messrs. Evans & McGregor, and is being manufactured by Messrs. James Evans & Company, Britannia Works, Blackfriars, Manchester.

DIMENSIONS OF FOUNDRY CUPOLAS.—The dimensions of the best working foreign cupolas are stated to average a section at tuyeres of 175 square inches per ton of output per hour, American practice being 260 square inches. A formula for the calculation of the pressure of the blast is $H = 50\sqrt{Q}$, where H is the pressure of the blast in centimeters of water and Q the volume of air supplied per second. Q should be proportioned to give the largest possible proportion to CO_2 in the gas. The total area of the tuyeres should be one-fourth to one-fifth of the area of the tuyere section. Under these conditions the coke consumption will vary between 9 and 11 per cent. of the weight of the iron melted. The limestone addition varies greatly in the different plants, from 27 to 40 per cent. of the coke charged.

PIG-IRON PRODUCTION IN GERMANY AND LUXEMBURG IN 1908.—The production of pig-iron in Germany and Luxemburg in December last, and the year 1908, was as follows, compared with the figures for the previous month and year:—

	Nov. 1908.	Dec. 1908.	Jan. to Dec. 1908.	Dec. 1907.	Jan. to Dec. 1907.
	Tons.	Tons.	Tons.	Tons.	Tons.
Foundry Pig-Iron and Castings	199,380	195,869	2,254,644	193,347	2,259,416
Bessemer Pig-Iron ...	20,856	22,177	361,472	38,838	471,355
Basic ,, ...	593,625	650,679	7,627,227	716,267	8,491,226
Spiegeleisen, Ferro-Manganese, &c. ...	72,215	98,110	934,940	86,759	1,034,650
Forge Iron...	44,662	49,691	635,228	68,164	786,113
Totals	930,738	1,016,526	11,813,511	1,106,375	13,045,760

As shown in the foregoing table, the year's production of every variety of pig-iron has come materially below that of 1907, though with the exception of foundry pig and direct castings the December figures are better than those for the previous month. Foundry pig-iron for the year fell 4,772 tons below the 1907 production; Bessemer iron was reduced by 109,883 tons, and basic by 867,000 tons. The decline in the production of spiegeleisen, ferro-manganese, ferro-silicon, etc., was 99,710 tons, while forge iron fell 150,885 tons.

The Problem of Bearing Metals.

By S. K. Patteson.

The constant increase in the demand for bearing metals due to wear and necessary replacements makes the question of supply one of the greatest importance. In addition, the quality of the bearings affects very largely the life of the machine itself, and in view of all these facts the value of intelligent and scientific treatment of the subject cannot be overestimated.

The data available is surprisingly meagre under the circumstances, and in very few cases is the composition of the bearing metal sufficiently considered with reference to the requirements demanded. In some cases the metals have been manufactured under patents and sold under trade names, but in the majority of cases they are made of scrap with very little care exercised in seeing that the proportions of the different constituents are the correct ones.

A considerable variety of metals, with a great range in the proportions of each exists in alloys used for bearings. Copper, lead, tin, antimony, and zinc are combined to form what are known as Babbitt metals, white metal, brass, phosphorus, bronze and various other trade alloys. A great majority of them are sold merely under trade names, and in many cases there is a considerable variety in their composition, even though of the same brand and sometimes in the same shipment. A few are sold under patents, but these form a minority of the total.

Bearing metals should have sufficient strength to withstand considerable strain and enough resisting power not to crack or break when subjected to heavy and sudden shocks nor to be crushed by pressure. In the selection of a bearing metal, however, special attention should be given to the local requirements.

The temperature plays a very important part here. If the metal is subject to extremes of heat and cold, with resulting contraction and expansion, binding may occur to such an extent that breakage may result from this cause. Again, extremes in temperature affect very seriously the brittleness, ductility, etc., of the metal.

Chemical action upon the bearings will also often result in injury, and in establishments, such as ammonia refrigerating plants or chemical factories, this factor should be borne in mind. These local effects are probably most severe in electrical machinery, where the bearings themselves must serve as electrical conductors, as in trolley cars and like installations. Elimination of friction and resistance to compressive loads have supplied subjects for investigation in machinery progress probably more than any other.

Thurston claims that all metals have the same friction, and the value of the soft white alloys for bearings lies chiefly in their ready reduction to a smooth surface after any local injury which might result from the introduction of foreign matter between a bearing and the pulley or moving surface. The injury is rapidly filled up by the metal flowing into it forming a larger area for the distribution of the pressure, and hence reducing the possibility of overheating, since the larger the bearing surface the less the likelihood of heating.

Hence, the lower the frictional properties of a bearing the less will be its compressive resistance to shocks and invariably alloys best suited for bearings from an anti-frictional, and, hence, speed point of view are the least satisfactory for utilisation in heavy machinery units. To overcome this difficulty an iron or steel grid has been recently introduced to form the base of the main bearing. This is filled with a much softer bearing metal than could be used under ordinary circumstances. This is a distinct step in the right direction and presents possibilities of great importance.

A number of metals possess good anti-frictional qualities, but lead is the first one on the list which is practically available, owing to the high cost of the others. Excluding, therefore, the costly ones, lead has the greatest anti-frictional properties of the available metals due to the fact that it flows more easily under pressure.

Lead, with the exception of iron, is the cheapest of the metals. Thus, the more lead a given bearing contains the softer it is, the better its anti-frictional qualities, and the cheaper it will be.

Lead cannot be used alone, however, as it cannot be retained in the recesses of the bearing, and various other metals have been alloyed with it, such as tin, antimony, copper, zinc, iron, and a number of known metallic substances, such as sodium, phosphorus, carbon, etc.

Experiments with these different compounds have given a fairly adequate amount of data as to their varying effects. Thus, antimony and lead produce a hard and brittle alloy. If tin is added to this it is toughened to a considerable extent. These three constituents are most common in the various bearing metals on the market.

If the proportion of antimony is increased, better wearing qualities and greater compressive strength result, making it more suitable for heavy machinery. Less antimony and more lead form a combination which is especially suited for high speeds because of the better anti-frictional qualities of the lead, While the addition of tin will increase the toughness of the bearing, it will also considerably increase the cost.

The steady increase in speed in the development of modern machinery creates a wide range of duty for the bearing metal. A great obstacle to the development of the modern turbine lies in the difficulty in securing proper bearing surfaces. Soft babbits are required for high speeds, and soft babbits will not stand the shock and strain of heavy machinery. On the other hand, the harder babbits suitable for heavy machinery present too great frictional properties, and it can be said that on the solution of these problems depends the increase in size and speed of machinery to-day.

Another phase of the subject which has probably not received the attention which it seems to warrant is the effect of temperature on the bearing properties of the alloys. Means for maintaining proper temperatures would undoubtedly result in great improvement. This subject is being investigated more especially in regard to turbine construction, however, since the speed in this development made the bearing problem an acute one. In fact, the efficient operation of the turbine can be said to depend upon a satisfactory solution of this question.

The following table gives in a general way the composition of the bearing metals commonly found on the market to-day: —

Alloys.	Lead.	Tin.	Anti-mony.	Cop-per.	Zinc.	Other constituents.
Babbitt 1 ...	80.0	20.0	—	—	—	—
Babbitt 2 ...	72.0	21.0	7.0	—	—	—
Babbitt 3 ...	70.0	10.0	20.0	—	—	—
Babbitt 4 ...	80.5	11.5	7.5	0.5	—	—
Babbitt 5 ...	0.5	68.0	—	1.0	31.5	—
Babbitt 6 ...	—	20.0	—	—	80.0	—
Babbitt 7 ...	—	86.0	10.0	4.0	—	—
White metal ...	82.0	—	12.0	6.0	—	—
White brass ...	—	61.0	—	2.0	34.0	—
"Magnolia metal" ...	80.0	4.75	15.0	trace	—	Bi=0.25
Car brass lining ...	80.5	11.5	7.5	0.5	—	—
"Ajax plastic bronze"	30.0	5.0	—	65.0	—	—
"Ajax metal"	11.5	11.5	—	77.0	—	—
P. R. R. car brass ...	15.0	8.0	—	77.0	—	—
"S. bearing metal" ...	9.5	10.0	—	79.7	—	P=0.80
"Delta metal"	5.1	2.4	—	92.4	—	Fe=0.1
"Carmelia metal" ...	14.8	4.3	—	70.2	10.2	Fe=0.5
Tempered lead ...	98.5	0.08	0.11	—	—	Na=1.30

The above table shows a wide variation in the composition of the various babbitts. The babbitt metal originally put on the market was a very expensive material. The cost, however, has been greatly reduced.

The first metal on the list, 80 per cent. lead, is not a very hard one, but one that is suitable for high speeds. Its melting point is about 500 degrees Fahr. In a general way the properties of all bearing metals can be readily deduced from their melting points.

The second babbitt is somewhat harder, containing 7 per cent. antimony, and a slightly larger per cent. of tin than the first. These two babbitts are favourites for lining purposes.

The fourth babbitt contains 20 per cent. antimony and is still harder. It is suitable for heavy machinery and is widely used for that purpose.

No. 6 has good wearing qualities, but is too hard for high speeds. In fact, all the babbitts will give satisfactory results in the positions for which they are especially suitable.

The white alloys possess a fairly good electrical conductivity. Tempered lead is harder than pure lead, but its anti-frictional qualities are supposed to be great, owing to a somewhat novel development. In operation the caustic soda formed by oxidation of the sodium in the bearing metal saponifies with the oil and thus assists lubrication. The extent to which this phenomenon affects beneficially the operation of the bearing has not been determined.

The other alloys given contain varying proportions of copper, tin, and lead, and when lined with a thin layer of lead or some soft babbit, wear much better than the softer metals. A large percentage of lead in an alloy tends to decrease the frictional effects, but pure lead is too soft to be used alone, and a certain proportion of other material is necessary.

The addition of tin increases the frictional effects and also increases the wearing qualities. Pure copper itself is so tenacious that it is practically impossible to work it with any tools without prior treatment and this property affects the bearing quality of any alloy of which it forms a part.

The above gives a general review of the bearing metal situation as it exists to-day. The possible variations in the composition of bearing metals are innumerable. Comparatively little data is available on this subject. A large number of metals, such as calcium, have been recently placed on the market, many of which possess very suitable properties for bearing metals, and this development is bound to influence the situation.

Interest is increasing in the scientific solution of the problem and various improvements along various lines may be looked for in the near future. Such devices as the steel grid and similar developments are steps in the right direction, and will undoubtedly aid in the solution of the problem.—("Electrochemical and Metallurgical Industry.")

CONCILIATION IN THE FOUNDRY TRADES.

A CONFERENCE of Lancashire engineering and foundry employers and members of the Executive Council of the Friendly Societies of Ironfounders of England, Ireland, and Wales, was held at Manchester, recently, to consider the question of the formation of a Conciliation Board for Lancashire and district. Mr. Matthews, president of the Employers' Federation of Associations, presided. The organisations represented included the Manchester Employers' Association, the Manchester Master Ironfounders' Association, the Bolton Employers' Association, the Oldham Employers' Association, and the Blackburn, Burnley, Preston, Wigan, Rochdale, and St. Helens Employers' Associations. After discussion it was agreed that the title of the new Board should be the Board of Conciliation for the Ironfounding Industry of Lancashire and District, and its primary object is stated to be to regulate general advances or reductions in the wages of moulders, and the condition of their employment providing such questions do not involve other trades. The representatives agreed that there should be no stoppage of work in the nature of a strike or lock-out, and that four weeks' notice in writing, terminating on a total pay-time day, should be given by the secretary of one party to the secretary of the other party on any question—including the termination of the Board—intended to be dealt with by the Board, and that no change in the general rate of wages should take effect until the expiration of eight months from the date of which the notice was given. Failing a settlement by the Board of any question referred to it by the Standing Committee, the same may by common consent be submitted to three disinterested gentlemen mutually approved by the Board, and their decision, or the decision of a majority of them, is to be binding and conclusive. If the Board fail to agree on gentlemen willing to act, each party will elect its own referee, and the two referees will nominate a third to sit with them, and their decision, or the decision of the majority of them, will be binding on the parties. The Conciliation Board consists of the following employers:—Messrs. R. Matthews (Manchester), chairman; W. Hodgson (Salford), A. Reason (Bolton), W. Livsey (Blackburn), Elijah Keighley (Burnley), J. H. Toulmin (Preston), T. A. Walker (Wigan), and L. A. Poritt (Rochdale); and the following representatives of the employed:—Messrs. A. Henderson, M.P., vice-chairman; F. Williams, secretary; J. Bell (Stockport), F. Forsyth (Barrow), A. Jolly (Warrington), J. Longfield (Burnley), E. Wilkinson (Manchester), and R. G. Williams (Liverpool).

MESSRS. THOMAS DUNLOP & SONS, 70, Wellington Street, Glasgow, have placed an order with the Northumberland Shipbuilding Company, Howdon-on-Tyne, for two steamers, each of about 7,000 tons carrying capacity.

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Moulding Machine for Making Street Lamp Posts.

A very interesting machine which has just been constructed by the London Emery Works Company, of Park, Tottenham, London, N., for making the moulds for street lamp posts, is shown in the two photographs herewith. The machine (Fig. 1) is of the turnover plate type, arranged to take mould-boxes 11 ft. 6 in. long by 14 in. wide, and the half pattern is fixed to one side of the turn-over plate, as shown in Fig. 2. The ramming of the box is in this case done by hand, whilst the extraction of the pattern is done by small hydraulic rams fitted in each of the side standards. The advantages possessed by the machine for these articles lie in the smoother castings obtained and in the increased rate of production, as compared with hand moulding.

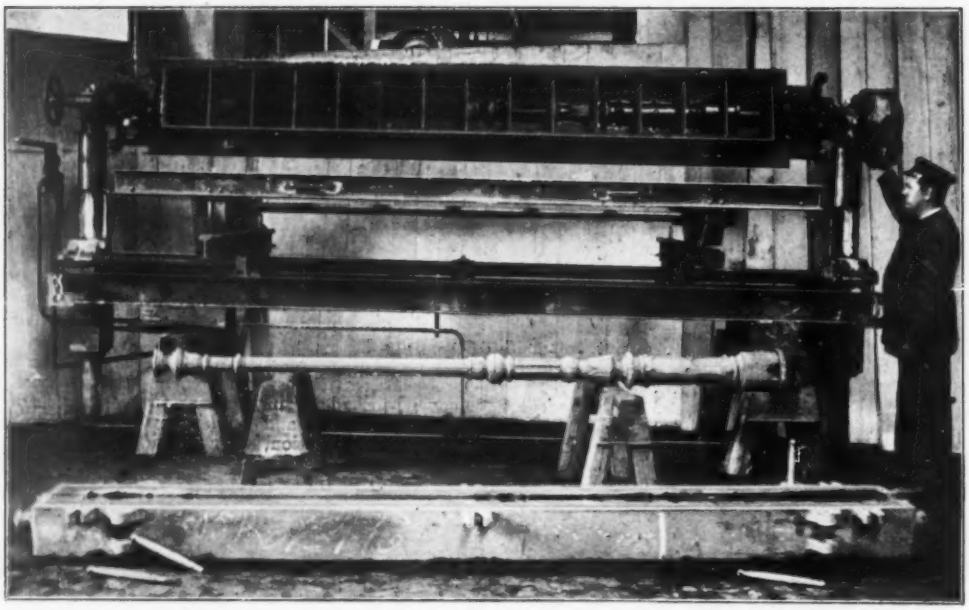


FIG 1.—MOULDING MACHINE FOR LAMP POSTS.

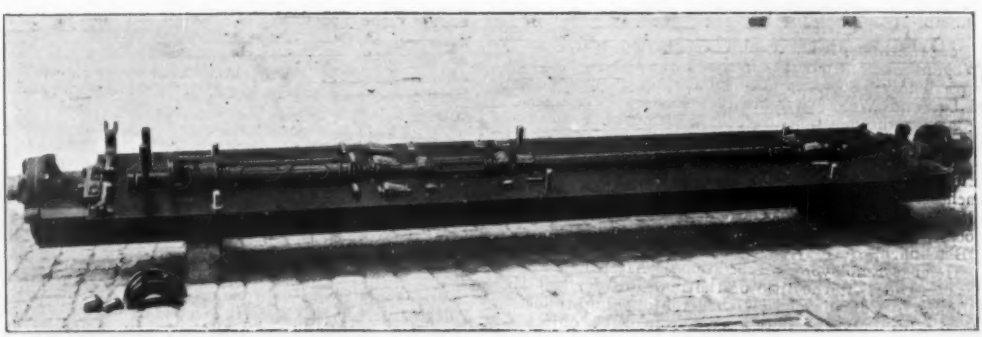


FIG. 2.—TURN-OVER PLATE; MOULDING MACHINE FOR LAMP POSTS.

As will be observed, the machine is erected on wooden struts to show the lower parts, but in practice it would be let into the ground up to the level of the trolley rails.

Chaplets: Their Use and Abuse.

By J. McCulloch.

Often do we see the stalks of chaplets being drilled, tapped, and plugged, to stop leaking, proving that chaplets are an evil—necessary in some cases, but in others not necessary. Often they could be done without, first by the moulder tying or bolting cores in position, second by the engineer allowing a plug or stud core to be used. Of course, the stud or core hole would have to be tapped and plugged, but it would be only one hole in place of many. Take, for example, a shell cylinder cover, Figs. 1 and 2. This cover made in the general way would have about three whole chaplets on each core, which would mean 36 stalks, and 36 chances of leaking in the test. A glance at Figs. 1 and 2 will show a method where no chaplets are used. The grid, Fig. 3, is first made, about $\frac{3}{8}$ in. or $\frac{1}{2}$ in. of loam all round it. A few chaplets may be used in this case on the bottom, but I have seen some very heavy cores resting alone on plug cores as shown. Fig. 7 shows a method for when the cores come through the top part. The core or cores are put in the mould on chaplets, and the top part put on. The core is then scotched down in three places at B, lifters C, C, being cast in the top plate, and D being made to sit on the top of the lifters E from core. Then scotch up the core at A, A, lift off the top, and take out all chaplets. This is a good method for box cylinder covers that have to be machined all over top.

Fig. 8 shows the tackle required for any long, square, or oblong core, such as distance pieces, con-

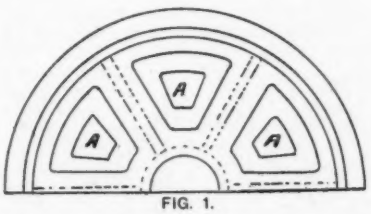


FIG. 1.

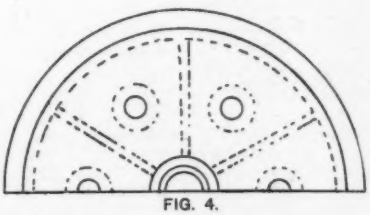


FIG. 4.

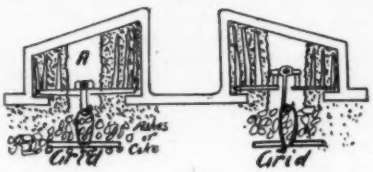


FIG. 2.

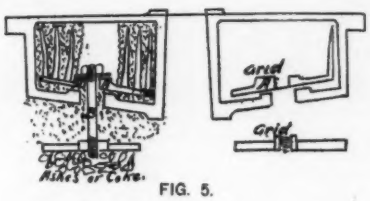


FIG. 5.

FIG. 3.

FIG. 6.

and lifters cast in at A, A, A, these being the centres of the cores. Put this under loam board or pattern, the lifters touching board or pattern. In stationary cores tie or bolt down the core grid right away; in others that require to be lifted to finish brackets leave a hole, as in Fig. 1 at A, A, A. Finish and bolt down, taking the vent in the same way. In Figs. 4 and 5 we have a piston with holes through the bottom. Of course, chaplets here really don't matter, so far as the engineer is concerned, but moulders will find this a pretty safe method, as there is practically no danger of metal getting into the vent. Make the core iron as in Fig. 3, but instead of lifters at A, A, A, cast in nuts, tapped to fit tube B, Fig. 5, and bed down the required distance from the pattern, putting two pieces of stick in the nuts as guides for finding them again. When making the core iron put on shoulder A, Fig. 5, to give a good seat for the washer under the nut. Fig. 6 shows a plug or stud core, it being of solid cast iron the required length, with densers, columns, etc. Make a grid to sit on the bottom, allowing a good bearing on ends, say, 12 in. to 18 in., and cast in two rows of lifters B, B, B, B, B, sufficient distance apart to allow a heavy bar or binder C to go down between them. Next wedge down with tuggles through the lifters, which gives a core bar with practically no yield in it. Next put on weight or weights A, A, bringing them to within $\frac{5}{8}$ in. or $\frac{3}{4}$ in. from the surface of the core. Then in the top plate or top part make provision for plugs D, D, to come right through the top. D, D, are either malleable or cast-iron rods, say, 3 in. diameter, wound with wire, and a thin skin of loam on them. In the binding of the job wedge down at D, D, and the core cannot lift. If any chaplets are desired on the bottom, chaplet rests E should be bedded in the bottom during finishing. These are just plates 2 in. by 6 in. by $\frac{1}{2}$ in. thick, with prods about $2\frac{1}{2}$ in. or 3 in. cast on, the heads of the chaplets resting on the points of prods. This method could

be applied to a good number of jobs, such as bend pipes, straight pipes, and round columns cast horizontally, etc.

In the case of a marine cylinder we often see chaplets all over the moulders' top (that is, the engineers' cylinder bottom), and a lot of them

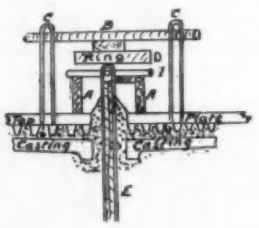


FIG. 7

leaking. No matter what size barrel or main core you have, don't put any chaplets on it; the centre core will hold it down. In fact, if over 50 in. diameter, it is better to wedge or bolt up the top of main core, or it will sink with the weight of metal on it. Don't put any chaplets on the sides of steam

long. Fig. 9 shows a good method of bolting down a top steam way. Make provision to bolt down to the top grid of the main core by casting in lifters D, and leave a hole through the steam way core for a bolt. Also bolt to the lower part of the steam way if cut there, but if the steam way core can be put

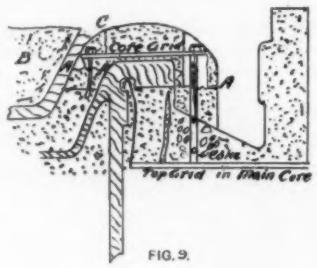


FIG. 9.

in whole before the top core B, then bolting to the main core is sufficient. In some cases the core is cut at A, A, and sometimes at C, but cut at A, A, is best, as you can stamp with soft loam or make up the joint, and thereby save a pin, which is often very difficult to cut out.

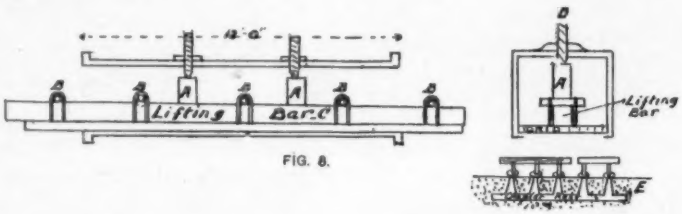


FIG. 8.

way cores unless they won't sit steady without. So far as the metal is concerned none are required, and in branch round cores a good many chaplets are thrown away; for if they have 1½ in. or over of a print, bolt them hard into the print, and it is nearly impossible for them to move unless they are very

These are only a few of the methods which might be adopted to save the use of chaplets being abused. And no doubt if the foreman or charge hand on any job just thinks of the consequences which follow the liberal use of chaplets he will manage to use without abusing them.

STANDARDISING REFRACTORY MATERIALS.

A MOVEMENT has been set on foot by the English Ceramic Society for a conference of representatives of the various technical institutes and societies, to consider ways and means of arranging for the grading and standardising, as far as possible, of the refractory materials, such as fireclay, magnesite, etc., used in the construction of furnaces, kilns, ovens, etc. The movement started in January, 1908, with the English Ceramic Society, and it received an impetus by the discussion which followed the reading of Mr. Bywater's paper at the Gas Institute last year. Dr. J. W. Mellor communicated with the secretaries of the different institutes, and representatives were appointed to meet at Stoke-on-Trent on January 4. Those present at the meeting included Mr. J. H. Darby, Iron and Steel Institute; Mr. J. Bond, Mr. F. J. Bywater, and Mr. E. Jones, Institute of Gas Engineers; Mr. C. W. Thomas, of E. J. & J. Pearsons, Limited, Stourbridge; and Dr. J. W. Mellor, of the English Ceramic Society. The following officers were elected:—Mr. J. E. Stead, F.R.S., chairman; Mr. J. H. Darby, vice-chairman; Dr. J. W. Mellor, hon. general secretary. The title of this body was provisionally fixed as "The Committee for the Standardisation of Refractory Materials." The general opinion of the representatives present was that there was need for such a committee, and that the following preliminary scheme should be adopted:—(*a*) To arrange and classify the various refractory materials, such as clay; siliceous, as silica and gannister; special, as magnesite, chromite, etc. (*b*) To arrange standard specifications for the raw materials and for the manufactured products. (*c*) To consider the possibility of arranging for uniformity in certain "stock" or "standard" sizes. (*d*) Standard methods of testing, analysis, etc. The industrial sections include the chemical and electrical section, metallurgical section (Iron and Steel Institute and Institute of Metals), gas engineers' section, and pottery section. The members of the Committee representing the various industries will formulate the demands of their own industry by inviting opinions on the following lines:—(1) Materials at present in use, any general information as analyses, etc. (2) Conditions of use, nature of furnace operations, temperature, and whether the temperature is continuous or intermittent. (3) Criticism of materials at present in use. (4) Suggestions as to improvement, both in material and in sizes and patterns available.

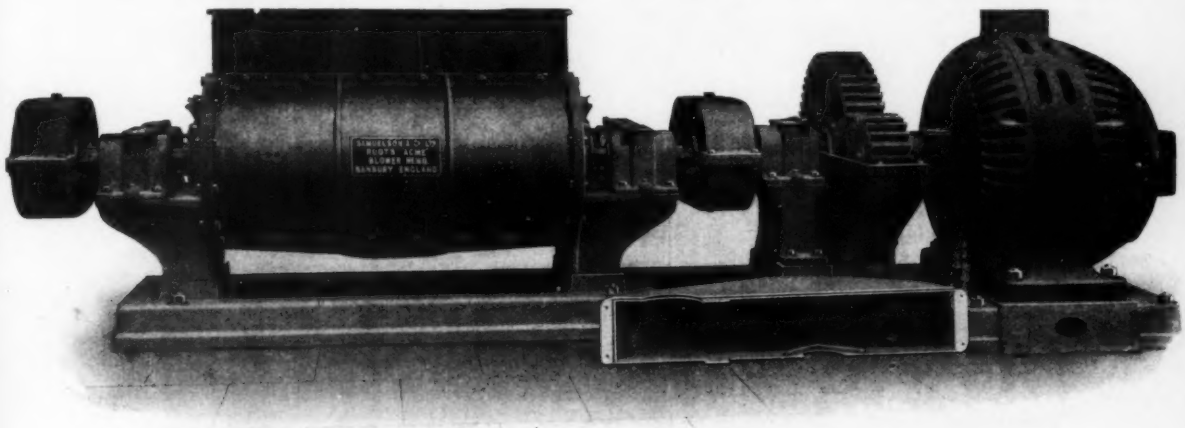
A High-Pressure Blower for Foundry Work.

In the illustration will be seen an electrically-driven high-pressure blower, made by Messrs. Samuelson & Company, Limited, Banbury. This "Acme" blower is composed entirely of metal, the revolvers, of which there are two, being each cast entire in one piece, without screws, bolts, nuts, or other parts that can become loose and cause trouble or injury. The wings of the revolvers, which are cut back to afford a clearance, do not touch the bottom of the recesses, but pass through the recesses without any obstruction whatever. The contact between the two revolvers and the case is maintained during the entire revolution, so that there is no backward escapement of air. This arrangement entirely prevents any danger of a collection of dirt or grease in the bottom of the recess, and any liability of thumping or pounding, or straining of spindles from this cause is entirely obviated. The revolvers, being entirely of metal, are unaffected by shrinkage or swelling from atmospherical causes, and hot or cold air can be passed through the blower without producing change.

With the electrically-driven blower there is a modification over the ordinary type in the shape of the revolvers, so that a shaft of larger diameter may be employed, with increase of size in the other working parts. The shaft is of special high carbon steel, having ample strength for the pressure which comes upon the revolver, etc.; and a special design of metallic packing ring is used at the end casing between the revolvers and the bearings. This packing ring prevents any possible leakage of air round the shaft, and is automatic in its action, the pressure being only such as is required to prevent any leakage of air, and is designed to obviate the wasteful friction and constant adjustment, with the consequent wear and waste of power caused by the ordinary type of stuffing gland when fitted with soft packing.

The bearings are made of a phosphor-bronze mixture, with an exceptional length to stand hard and continued wear, and are fitted into the cast-iron pedestals which are carried on substantial brackets, cast on the end casings of the blower. This construction makes the use of outer bearings entirely unnecessary, and these are not employed, except for the driving shaft which carries the spur wheel when the machine is driven by motor, as shown.

These blowers have been supplied for such purposes as the "Tropenas" process of steel-making, and other processes where as much as 10 lbs. pressure of air is required.



THE "ACME" HIGH PRESSURE FOUNDRY BLOWER.

A DISSOLUTION of partnership is notified in connection with Messrs. H. Kear & R. Turner, engineers, etc., Bristol, who traded under the style of S. Kear & Company.

MESSRS. W. BRANDON, J. R. HILL, and W. BARNES, stove manufacturers, etc., Birmingham, trading under the style of W. Brandon & Company, have dissolved partnership.

THE late Mr. Henry Chapman, M.I.C.E., M.I.M.E., of 69, Victoria Street, London, chairman of the General Hydraulic Power Company, Limited, and lately vice-president of the Institution of Mechanical Engineers, left estate valued at £187,464 11s. gross, with net personalty £185,606 9s. 5d.

MESSRS. WILLANS & ROBINSON'S WORKS at Rugby have been actively engaged during the past few months in the manufacture of exhaust steam turbines, a number of which have been at work in different parts of the country. Some of the largest turbines yet built in this country for working with exhaust steam have recently been put into commercial operation by Messrs. Willans & Robinson, in the works of Sir Bernard Samuelson & Company, in Middlesbrough, these being designed for giving an output of 1,350 kilowatts each.

The Baumann Tilting Crucible Furnace.

We illustrate herewith the Baumann patent tilting crucible furnace with which, it is claimed, 2 cwts of copper, bronze, or brass, either in ingots, strip, scrap or borings, can be melted in 10 to 20 minutes, with a fuel consumption of 15 to 20 per cent.

The construction of the furnace enables the waste heat and gases to be utilised to heat the metal before it passes into the crucible. This is effected by means of a hopper or charge-heater, through which the metal is fed into the crucible, and the heat generated by the waste gases passing through this charge-heater softens the metal by the time it passes into the crucible. The crucible is never handled by tongs, and is never taken out of the furnace and exposed to the cold atmosphere; accordingly its life is prolonged. It is held securely in place in a shell lined with firebrick, and there is no danger of its being displaced at any time.

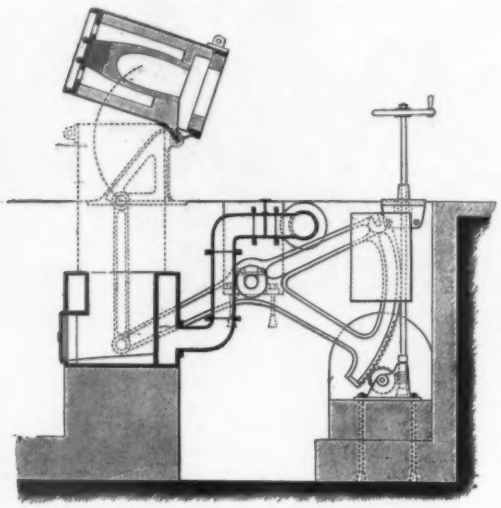


FIG. 1.—BAUMANN TILTING CRUCIBLE FURNACE; SECTIONAL ELEVATION.

The furnace is mechanically lifted and then tilted, and the molten metal poured into a ladle or direct into a mould.

The raising and tilting mechanism (see Fig. 1) is very simple, and easy to manipulate. The centre of the turning shaft is arranged in line with the pouring spout, so that the latter when pouring is always in the same position. Only one man is required to operate the tilting and lifting mechanism, and being right in front of the ladle or pouring crucible, he can at all times properly regulate the flow of metal. The grate is designed so that cleaning may take place during the operation of melting.

The design of the charge-heater varies according to the metal to be melted and the form in which it is to be introduced into the furnace. The passing of the heat and gases through the charge-heater can be prevented if desired, to effect which it is only necessary to regulate the blast by means of the blast valve.

Instead of the usual brick ashpit, the Baumann furnace (see Fig. 2) has an ashpit of cast iron surrounded by an air chamber, so arranged that there will be a uniform air pressure under the fire grate, and therefore in the furnace.

Another point of great importance in the construction of the ashpit is a spout at the base of the pit, for the purpose of preventing waste of metal in case of a crucible fracture. The base of the ashpit inclines slightly towards this spout, which is sealed by a lead plug, and in case of a crucible breaking the molten metal drops through the grate on to the base plate of the ashpit, melts the lead plug, and runs out into a ladle kept ready for this purpose outside the ashpit. This is shown in Fig. 2.

This illustration shows the furnace with a charge-heater for brass and scrap and with the ashpit above described. A is the furnace showing firebrick lining; V is the grate plate; W is the crucible bed with projections fitting into the base of the crucible so that by means of this, and the firebrick X, and the segments X^1, the crucible is firmly held in position when tilted. The space between the crucible and the firebrick lining of the furnace is filled up with coke; a^2 is the tapping spout, r the runner, y a ring of firebrick in segments.

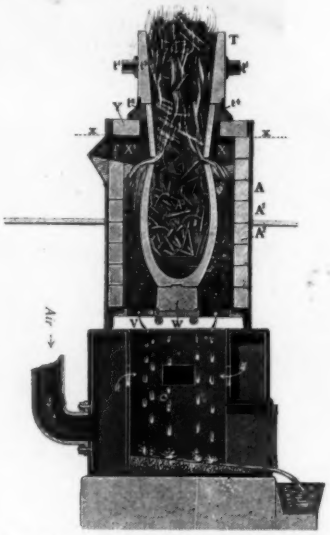


FIG. 2.—BAUMANN TILTING CRUCIBLE FURNACE; SECTIONAL VIEW OF FURNACE AND ASHPIT.

The charge-heater consists of a sheet-iron hopper T surrounded with a cast-iron ring t^2; it is lined with fireclay t^3 and t^4, and holds securely the funnel-shaped plumbago tube set into it. Lugs t^1 are provided into which rods are inserted to lift and remove the charge-heater from the furnace. By removing the fireclay lining t^4, the plumbago tube can be removed and renewed when necessary.

Operating the Furnace.

The heating, charge-heating and melting process is as follows:—A small spout is first chipped in the crucible for convenience of pouring. The crucible must be placed in the furnace exactly in the centre

so that the coke will surround it evenly. The furnace is fired in the usual way; the blower is then started, slowly at first, and the blast gradually increased until the crucible is red-hot all round. The blower is then stopped, the burning coke raked over, and new coke filled in, until the coke is right up to the top of the crucible, care being taken to have no hollow spaces. The cover is removed from the crucible and the metal to be melted is charged. The charge-heater is then put on in such a way that the lower opening of the plumbago tube is just over the top of the crucible with a little space between the crucible and the tube. A tight joint is now made between the furnace and charge-heater by daubing with loam, and the pouring spout is closed with a firebrick plug and loam, thus keeping the flames in the furnace and maintaining their right direction.

The rest of the metal is now fed into the charge-heater and the blower started slowly. The air under pressure enters through the grate and the tuyeres, and, impinging with the gases and flames on the firebrick segments at the top of the furnace, forces the former to pass through the charge-heater and the charge. The metal in the charge-heater soon becomes red-hot and soft, and falls by its own weight into the crucible where it speedily becomes fluid. In this manner the melting is exceedingly quick, and because the metals are only exposed to the flames until they become red-hot, there is no chance of oxidation of any easily oxidisable metals which may be constituent parts of an alloy being melted. As soon as the melting is finished, the charge-heater is removed, the tapping spout opened, the metal poured, and when the crucible is emptied all is in readiness for a fresh heat.

Care should be taken to weigh the right quantities of metal into the furnace, as the crucibles must not be charged beyond their rated capacity. It is not necessary to have a chimney to create a draught, as the necessary air pressure is obtained by means of the blower. In order to carry away the fumes and waste gases a sheet-iron smoke stack is placed over the furnace. The quantity and pressure of air required for good results is about 700 cubic feet of air per minute at water column pressure of 4 to 5 cm.

After every seven meltings it is necessary to clean the ashes, etc., from the grate; if cleaning should be required while the furnace is in use, a hole of about $2\frac{1}{2}$ in. diameter should be driven through the coke in each corner of the furnace, thus giving the blast a better passage, and enabling the day's work to be completed.

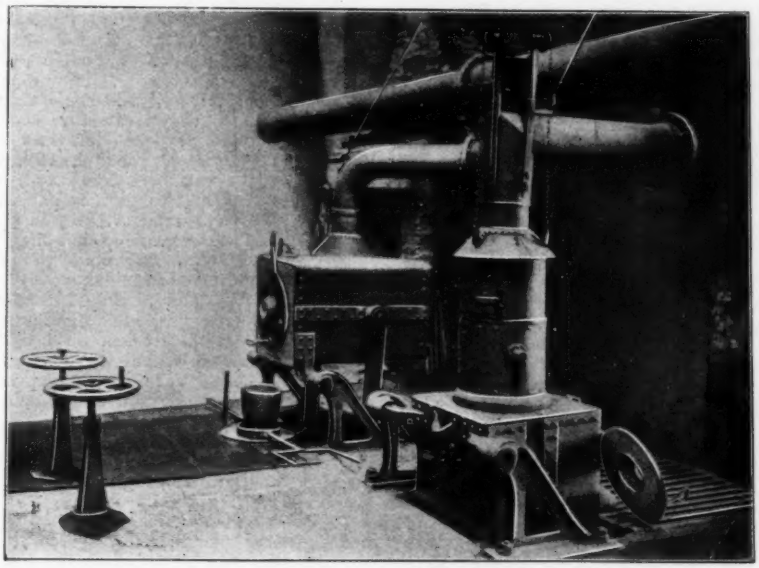


FIG. 3.—BAUMANN FURNACES AT THE SKODA WORKS.

The crucibles used in the Baumann furnace are of a type specially designed for the purpose. Crucibles, crucible stands, graphite cones for the charge hoppers, and the furnace linings, are all treated with a special preservative, which has the effect of greatly increasing their fire resisting qualities. The furnace lining has to be renewed after 200 meltings. The furnace is made for crucibles having a capacity of 2 to 10 cwts.

The apparatus is being introduced into this country by the Simplex Coke Oven and Engineering Co., Ltd.

THE first annual dinner of the staff of the Brightside Foundry and Engineering Company, Limited, of Sheffield, was held last week. Many of the directors were present, including Mr. T. H. Firth, managing director, who, in responding to the toast of "Success to the Firm," mentioned that the company had had a very rough time during the last six months, but he thought there was a better period before them. They had taken orders from South Wales for castings machined, and if any one had told him 18 months ago that they would have looked at the price for the castings alone, without any work done on them, he should have doubted it. Still, he believed they would make a profit, because they were all pulling together.

The Institute of Metals.

Meeting in London.

The second meeting of the Institute of Metals, the newly-formed organisation which devotes itself especially to non-ferrous metals, was held in London on Tuesday and Wednesday, January 19 and 20. The proceedings were in the main devoted to discussions on the series of papers read at the inaugural meeting in Birmingham, which was reported in our last issue, and were presided over by the President (Sir William White). The attendance was not so large as in Birmingham, those present including the following:—*Members*: Dr. H. C. H. Carpenter, Professor W. Gowland, Professor T. Turner, Professor T. K. Huntington, Messrs. J. T. Milton, W. H. Johnson, T. A. Bayliss, R. K. Gray, J. H. Wilson, G. B. Hunter, H. Oram, C. C. Bamford, E. S. Reid, R. J. Brown, C. Billington, H. M. Martin, R. F. Hartley, J. B. George, O. Vivian, T. G. Hirst, W. R. Barclay, R. Pearce, T. Cookson, G. Baedikker, A. E. Seaton, W. H. Robertson, W. B. Stanter, C. O. Bannister, G. Matthey, J. W. Earle, J. J. Edwards, B. J. Niggemann, E. J. King, T. T. Dunn, C. F. Gaywood, F. A. B. Lord, L. H. Harburg, W. Rosenhain, O. F. Hudson, F. W. Harbord, W. M. Morison, C. H. Desch, A. Bleckley, and E. T. Schneider. *Visitors*: Messrs. E. Payne, A. H. Hoare, T. E. Kershaw (Montreal), J. Anderson, F. R. Chalmers, W. Defries, J. Echevarri, E. Worthington, A. Philip, C. Weiss, A. Arundel, J. Rowley, R. J. Walker, R. N. Lennox, and J. W. Lane.

Professor Turner read the Honorary Treasurer's report, covering the first half-year's work, which stated that the funds were in a thoroughly healthy condition, the total receipts being £665 2s. 4d., and the payments £234 12s. 3d., leaving a balance in hand of £430 10s. 1d. Subscriptions had been paid by 273 ordinary members, and five student members, while the contributions to the special fund for defraying preliminary expenses amounted to £82 5s. 6d., sufficient to repay the whole cost of printing, advertising, and clerical assistance incurred by the Honorary Secretaries in the formation of the Institute. It was hoped that other contributions would be received to cover the cost of furnishing the new offices, and so allow the whole of the current subscriptions to be used for the more direct prosecution of the aims of the Institute. Subscriptions from 76 ordinary members were still outstanding. On the other side, about £200 would be required for secretarial and office expenses to the end of June next. The remaining sum would be available for other purposes, and particularly for the publication and distribution of the "Journal" of the Institute, the form of which had yet to be determined. It would be necessary to considerably increase the annual income if the objects of the Institute were to be adequately met. Professor Turner remarked that it was a pleasant task to present so favourable a report.

The President announced the following elections:—*President*, Sir William White; *Vice-Presidents*, Messrs. H. S. Bonner (London), H. Cookson (Newcastle-on-Tyne), Professor W. Gowland, F.R.S. (London), Sir Gerard Muntz (Birmingham), Vice-Admiral H. J. Oram (London), and Sir Henry A. Wiggin, Bart. (Birmingham); *Council*: Messrs. G. A. Boeddicker (Birmingham), J. A. Bayliss (Birmingham), and J. Corfield (Swansea), Dr. F. Elgar (London), Messrs. R. K. Gray (London), J. T. Milton (London), and E. Mills (Swansea), Professor T. K. Huntington (London), Messrs. G. N. Nisbett (Prescott), E. Ristori (London), A. E. Seaton (Birmingham), and C. H. Wilson (Sheffield), with Professor T. Turner (Birmingham), as *Hon. Treasurer*, and Dr. H. C. H. Carpenter (Manchester), and W. H. Johnson (Manchester), as *Hon. Secretaries*.

The President, continuing, said the voting papers had been very numerous, and the voting had been practically unanimous. It was very satisfactory that the names put forward by the Interim Council had secured the unanimous approval of the members. They had endeavoured to include all branches of the metal trades upon the Council. There was one sad item in the list. Since the voting papers were received his fellow-student and life-long friend, Dr. Elgar, had died suddenly while taking a holiday at Monte Carlo. They had looked forward to his assistance as being of the greatest value to the Institute, and it would be necessary for the Council to fill the vacancy. A suggestion had been made at Birmingham that the members who were not charged an entrance fee should voluntarily pay the amount. He thought, through inadvertence, many of them had overlooked the suggestion, but he hoped it would still be taken up, as they would then be able to start fairly. The Council would have to form a publication committee, and he hoped that the "Journal" would prove very valuable in the very important work they had undertaken on behalf of the metal trades. They were under a deep obligation to Sir Gerard Muntz for furnishing a paper on "The Relation between Science and Practice, and Its Bearing on the Utility of the Institute of Metals." Sir Gerard had fulfilled the promise, notwithstanding the lamented death of his father, but that event prevented Sir Gerard being with them, and he would reply in writing to the discussion. Other apologists included Sir Henry Wiggin.

Sir William, again referring to the late Dr. Elgar, mentioned that on January 16 he received from Mrs. Elgar a note written, at the doctor's request, conveying apologies for absence and his best wishes for the success of the Institute. That letter must have been written very shortly before his unexpected death.

Science and Practice.

The Secretary (Mr. G. Shaw-Scott) then read the paper by Sir Gerard Muntz, referred to above. The writer remarked that there had hitherto been no home for the non-ferrous metals, and they had been Ishmaelites, the hand of each man being against his neighbour, while the sharing of knowledge and useful discussion had been notably absent. The greatest benefits would come from the combination of the manufacturer, the scientist and the engineer. The scientist had the advantage of time and opportunity to reason out obscure and difficult subjects, while the engineer was largely guided by experience. Probably if engineer and manufacturer had placed confidence in each other and discussed the uses of certain materials, the latter would never have been employed, and much trouble and expense would have been saved, while the scientist could have been called in to make independent investigations. Considering the multiplicity of uses for non-ferrous metals, and the lapse of time since they began to be worked, it was remarkable how little was known of copper and its alloys.

The papers at the first meeting, while interesting and valuable, gave, with one exception, information too intricately involved and scientific for practical service in manufacture. It was necessary to bring science into touch with practice, and for the man from the laboratory to assimilate a personal practical knowledge of the processes of manufacture. The knowledge gained needed to be made readily available, while, as to trade secrets, those inparting useful information would probably learn a dozen things in exchange for the one given away. By breaking down the barriers of narrow-minded selfishness there was no doubt as to the usefulness and successful future of the Institute.

At the suggestion of the PRESIDENT, a vote of thanks was accorded Sir Gerard Muntz for his paper.

MR. MATTHEY, in the discussion which followed, thought research work was not sufficiently encouraged, but there had also been deficiencies in making use of the knowledge available.

MR. COOKSON did not agree that it was the duty of the research man to suggest the application of knowledge. He should follow the principle that "the cobbler should stick to his last". The manufacturer should take care that his scientific staff made use of their knowledge. His own firm had received the greatest possible benefits from research work in many ways, especially from the revelations as to the effect of bismuth. For that they were deeply grateful, and he wished the investigators would hnd out half a dozen things as valuable.

The discussion was continued by MESSRS. ROSENHAIN, BAEDIKKER, SEATON, and others

PROFESSOR TURNER expressed has amusement at the suggestion in the paper that the University professor or investigator was "embowered in that cloistered seclusion which allows of consecutive thought and reasoning out of obscure and difficult subjects", giving illustrations, pointing in another direction, from his own experience as Head of the Metallurgical Department at Birmingham University.

THE PRESIDENT regretted that the so-called popularisation of science was often carried out by people who had never themselves got below the surface of knowledge. As among the best examples of true popularisation, the speaker instanced the works of Professor Tyndall on "Light," "Heat," "Sound" and so on.

Copper and Copper Alloys.

The next paper discussed was the one by Mr. J. T. Milton, on "Some Points of Interest Concerning Copper and Copper Alloys."

MR. SEATON drew attention to the ancient forms of bronze as showing the great value and importance of time in the preparation of the bronzes. He thought they were expecting more from what was called the "treatment" of metals than they were entitled to.

Other speakers contributing to the discussion were MR. TOMLINSON and PROFESSOR GOWLAND. The latter considered that the smoky atmosphere in which certain coppers had been annealed was accountable for the extreme brittleness exhibited. The speaker gave instances of the corrosion of locomotive tubes which was found to be due to the fact that the fuel used had been exposed to the action of sea water.

MR. ROSENHAIN thought that in some cases brittleness was due to the introduction into the metal of a foreign body such as a filing or a shaving.

MR. MILTON briefly replied.

Aluminium.

The evening meeting on Tuesday was devoted mainly to the consideration of the paper by Mr. J. T. W. Echevarri, on "Aluminium & Some of Its Uses".

MR. RISTORI recalled the time when the metal cost 55s. a pound, and the whole output of the year was not more than three tons, whereas it had now increased to 30,000 tons. It ought to be much more widely used for shipbuilding, seeing that it was only one-third of the weight of other metals. But it required to be in a form more readily applicable to such purposes. The speaker related an amusing example of an attempt to make a propeller, which was rejected by the Inspector of Marine because it was full of blow-holes.

The discussion was continued by DR. CARPENTER, MR. MORRISON, and MR. MILTON. Several speakers referred to the difficulty of soldering the metal, PROFESSOR TURNER declaring that if a satisfactory solder could be produced, it would go a long way towards popularising the metal. After remarks by MESSRS. SEATON, and JOHNSTON, the PRESIDENT dealt with the question of utilising aluminium for shipbuilding purposes. His own experience was that it had always proved unsatisfactory on the side of corrosion. Obviously it was a very desirable metal on account of its lightness, and it had proved very satisfactory away from the water, but wherever it had come into contact with the water the rapid disappearance of the metal had made it impossible for general application. It had been used very satisfactorily in such vessels as racing yachts, where the sole object was to win a race and the lifetime of the vessel was a matter of no importance. He believed that some day the difficulty would be got over, but the method had yet to be discovered. If they could combine durability with the other good qualities, users would only be too glad to employ the metal.

MR. ECHEVARRI, briefly replying, said a number of aluminium-bronze propellers had been made for the French Admiralty which had given every satisfaction.

Other Papers.

The remainder of the Session was devoted to a discussion on the paper jointly contributed by Messrs. G. D. Bengough and G. F. Hudson, on "The Mechanism of Annealing in the Case of Certain Copper Alloys."

At the concluding Session on Wednesday morning, there was a lengthy discussion on the paper contributed by Mr. Philip, on "Some Notes on Phosphor Bronze."

PROFESSOR HUNTINGTON said he had found the metallographic method of determining the amount of phosphorus sufficiently approximate for practical purposes. The effect of phosphorus appeared to act chiefly in the removal of oxygen.

MR. SEATON said the metal had been a somewhat disappointing one, being quite unable to compare with white metal for bearings.

MR. BILLINGTON thought copper was frequently deteriorated through the pouring arrangements, which allowed a mixture of oxygen and slag in the metal.

Other speakers complained of variations of quality, for which explanations were not readily forthcoming.

MR. PHILIP briefly replying, expressed his strong hope that those who had information to give on the subject would come forward with it.

THE PRESIDENT said they were greatly indebted to the Admiralty and to Mr. Philip for the valuable information furnished.

A discussion followed on the papers contributed by Mr. Walter Rosenhain on "The Metallographic Investigations of Alloys," and by Mr. Cecil H. Desch, on "Inter-Metallic Compounds," these papers being jointly discussed. A personal element was introduced into a highly technical discussion through a complaint by Mr. Law as to a criticism made by Mr. Rosenhain on certain methods employed by Professor Tammann. The speaker thought the criticism would have come

better from an older man. The comments by the reader of the paper were strongly defended both by Professor Turner and the President, the latter holding that a well-reasoned argument such as that brought forward by Mr. Rosenhain, against any method, was entirely justifiable and was not likely to be objected to by Professor Tammann. Such criticisms were well within the object of the Institute.

The allotted time having now expired, it was agreed to reserve the discussion on the remaining paper—that by Mr. W. H. A. Robertson on "Plant Used in the Manufacture of Tubes"—for correspondence in the "Journal."

The PRESIDENT, in his closing remarks, announced that the Council had filled the vacancy caused by the the death of Dr. Elgar by appointing Dr. Hutton, of Sheffield, to the position. He represented a most important branch of the industry in Sheffield. The Council had authorised himself, on behalf of the Institute, to communicate to Mrs. Elgar their sympathy and regret at the death of Dr. Elgar.

On the PRESIDENT'S suggestion, a vote of thanks was accorded the Institution of Mechanical Engineers for the use of the building in which the meetings were held.

The PRESIDENT remarked that he thought they would agree that the Institute had made excellent use of their time, as was shown by the high character and great interest of the discussion, and the method of reserving the discussion of the papers for London had been amply justified. Material had been provided for an excellent first volume of their "Proceedings," which would include many important communications in writing. They had made what everybody would agree was an excellent start in the career of the Institute.

Technical Education at Cardiff.

Of all the irons in the municipal fire at Cardiff at the present moment, there is not one claiming closer attention, or gaining more popular favour, than the movement for the provision of up-to-date technical instruction for the youths of the city. The City Council, through its Technical Schools Committee, recently re-organised the whole of the machinery, and, under the direction of Mr. C. Coles, the Superintendent of Technical Education, the classes are showing excellent results. On the Technical Schools Committee, amongst the co-opted members, is Mr. T. Hurry Riches, a Past-President of the Engineers' Institute,and it was mainly through his initiative that the Committee conceived the idea of approaching large employers of labour in the city in order to enlist their sympathies and induce them to influence their apprentices and others to take advantage of the technical classes.

No one has responded more enthusiastically to the advances of the Technical Schools Committee than Mr. Charles Jones, of the Ninian Foundry. Mr. Jones, in order to ensure success for the classes formed in metallurgy, iron-working, inorganic chemistry, and kindred subjects, recently organised a meeting of foundry operatives, at which the Chairman of the Technical Schools Committee (Councillor Joseph Stanfield), Mr. T. Hurry Riches, Mr. Coles, and other leaders of the movement, could meet the apprentices, and others, face to face, and discuss the necessity for technical instruction in an informal manner. The meeting was held on January 7, and was an unqualified success. In addition to the gentlemen already mentioned, there were also present Sir Wm. S. Crossman, an ex-Lord Mayor, Councillor John Chappell, representatives of the Cardiff-Dowlais Works (Messrs. Guest, Keen & Nettlefolds), the Taff Vale Railway Company, and representatives of other large local firms in the iron and steel trades.

COUNCILLOR STANFIELD, Chairman of the Technical Schools Committee, presided, and expressed the very earnest desire of the Committee that the facilities provided would be taken full advantage of by the foundry operatives. The Committee would welcome any suggestion from even the youngest apprentice present in the direction of popularising the classes, and the Superintendent (Mr. Coles) was always ready to advise them as to the particular course of study they should pursue.

MR. T. HURRY RICHES said that the future success of Great Britain in the world's great industrial race is absolutely dependent upon the extent to which the rising generation will avail themselves of the advantages of technical instruction. "The finest castings I ever saw in my life," he said, "came from the Malay Peninsula, and I have now at home castings from Borneo such as I question whether anyone in this room could produce. People speak of the lack of education in Russia, but if you want fine artistic castings I do not know of any country in Europe where you will find better castings. So you see that foreign countries have fully appreciated the value of technical knowledge, and we cannot afford to allow our young men to ignore the value of metallurgy and inorganic chemistry."

SIR WM. S. CROSSMAN spoke with equal emphasis, and speeches were also delivered by Mr. C. Coles, the Rev. Blount Mott, and Mr. Charles Jones, the latter making the promise that, provided those attending the classes in ironwork are regular in their attendance, he would take thirty of them on a visit to one of the largest foundries in the country, free of all expense.

MR. C. E. BLACKMORE, of the Taff Vale Railway Company's Foundry, impressed upon the junior members of the trade the necessity of availing themselves of the advantages offered to them, and urged the foremen and managers present to use their influence in making it as convenient as possible for the lads to attend the classes regularly.

A hearty vote of thanks was accorded to Mr. Charles Jones for his work in connection with the meeting.

Steel Castings.

By Otto Beckmann.

Of late years the requirements enacted of structural iron castings have become more and more stringent, and dimensions employed have reached such proportions, that to ensure the requisite degree of safety it has, in some cases, been found necessary to substitute a stronger material, namely, steel. The first to use steel in the production of castings was Jakob Meyer, of Bochum, who succeeded, after prolonged endeavour, in turning out steel castings of a quality that satisfied the requirements of the time. The defects of these early products were mainly due to the quality of the steel itself, and have now been overcome to such an extent that the more rigorous specifications of the present day can be satisfied. and steel castings of all sizes and degrees

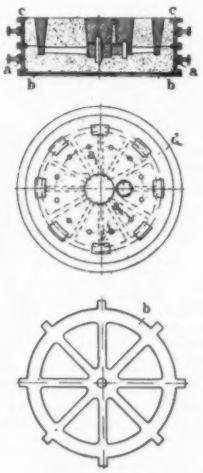


FIG. 1.

of hardness can now be turned out without any special difficulty.

In some respects, steel castings are more difficult to produce than those of grey iron, for three chief reasons :—In the first place, the moulds must be of some material that will bear great heat, the pouring temperature for steel being between 1,400 degrees and 1,500 degrees C. Then, owing to the tendency of the metal to form cavities in the head of the mould whilst cooling, larger gates are required, to serve partly as a reservoir of liquid metal; and, finally, the stresses set up in the castings whilst cooling have to be prevented by detaching the castings from the sides of the moulds, which prevent unrestricted shrinkage.

The moulds must be made of material that will not fuse or sinter at the pouring heat of the metal, preference being given to a mixture that is also plastic and permeable. The heat-resisting power is imparted by burnt fireclay, crucible sherds (from the crucible-steel plant), or broken porcelain, the plasticity being obtained by an addition of unburnt clay or potters' earth, whilst graphite and coke have been found useful for ensuring porosity without loss of heat-resisting power.

There are various recipes for compounding these mixtures, of which the following may be taken as typical examples :—

1. Firebrick, 12 parts; best clay, 3 parts; silver sand, 3 parts; graphite, 1½ parts; a little common sand being added to increase the porosity.

2. Crucible sherds, 40 parts; best clay, 10 parts; quartz or silver sand, 30 parts; powdered coke, 10 parts.

3. Firebrick, 12 parts; crucible sherds, 4 parts; best clay, 3 parts; graphite, 1½ parts.

4. Quartz 8 parts; best clay—which may also be replaced by syrup or treacle—10 parts; coke, 10 parts.

The degree of heat-resisting power required—and this is the most important factor of the moulding composition—is determined by the thickness of the castings and the pouring heat of the steel; this in turn depends on whether the steel has been made in

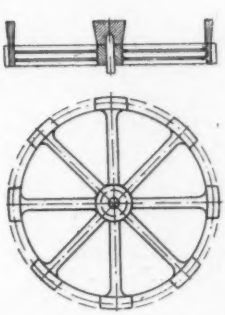


FIG. 2.

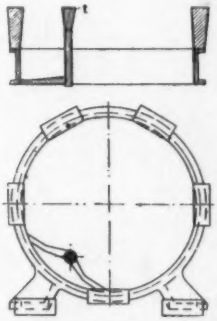


FIG. 3.

a crucible furnace or by the Small-Bessemer process. The thicker the casting the longer the time taken by the steel to solidify, and therefore the greater the action of the heat on the walls of the mould. Crucible steel does not require moulds of such highly refractory character as steel made in the open-hearth furnace or small converter. These considerations should be borne in mind when selecting the moulding composition, because they affect the cost of production. A certain degree of economy can also be effected by using old firebrick from dismantled furnaces, and the portions of old moulds that have stuck to the castings.

As regards moulding, the gates must be large enough to hold a quantity of metal equal to 30 to 50 per cent. of that in the actual castings, instead of about 5 per cent., as in the case of grey-iron, on account of the risk of the formation of cavities in cooling. As it is sometimes necessary to make the gate area nearly, or quite, as large as the top of the casting. The mould boxes must be shaped differently, the traverses having to be reduced in number, or abolished entirely, so as not to be in the way of the gates. In order to retain the moulding composition in the boxes, the latter must be built up.

Steel castings are generally made in double boxes, firstly, in order to enable the moulds to be dried in the oven (the cheapest method), and secondly, to facilitate detaching the castings from adherent

particles of moulding sand. Only heavy and broad castings are moulded and cast in the floor. The system of producing the various types of castings is elucidated below by the aid of typical examples, drawn from practical experience.

Locomotive and Toothed Wheels.—The method of moulding the wheel shown in Fig. 1 may be assumed to be known. It may, however, be pointed out that, as the box has no traverses, the moulding composition in the bottom box *a*, is held in place by means of a cast-iron plate, *b*, a plan of which is given in the lower part of the illustration. This plate is attached to *a*, by means of clamps and wedges. The composition in the upper box *c*, is held in position by inserted iron bars and hooks. The most important operation in making this part of the mould is the arrangement of the gates, which are preferably situated where the greatest thickness of metal is wanted, namely, at the hub and rim. The steel is poured in through the hub gate, thus dispensing with the necessity for a special pouring gate. Since the rim and spokes of the wheel, being thinner than the hub, begin to contract soomer, care must be taken to allow them freedom to shrink, by removing the sand or moulding composition from between the spokes. Detachment is facilitated by leaving a number of holes, a^1, between the spokes when the mould is being made, so that when the hub begins to shrink

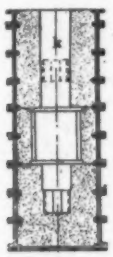


FIG. 4.

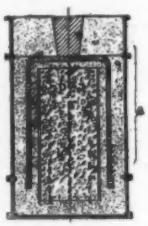


FIG. 5.

at a later stage, the spokes and rim can follow its contraction, in consequence of the absence of resistance by the walls of the mould. This precaution prevents the hub from tearing away from the spokes.

The moulding arrangement of the gates, pouring and detachment are similar in the case of the pinion illustrated in Fig. 2, to those just described.

Fig. 3 represents a pole-ring for a dynamo, and shows the arrangement of the gates. The pouring is preferably effected through a separate gate, *t*.

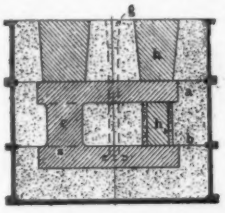
Fig. 4 shows a helical pinion, with waste head *k* at the upper end of the coupling shank. The shaft being comparatively long, the gate must be correspondingly deep; and a solid casting is obtained by repeated feedings.

The gate for the vessel illustrated in Fig. 5 can be small, the walls of the vessel being comparatively thin (1¼ to 2½ in.), and may also be used for pouring. In the case of these hollow vessels, attention must be concentrated mainly on the shrinkage, to facilitate which a bed of coke, *k*, is provided inside the core and is held together by rods, *p*. When the steel has solidified after pouring, the upper part, *a*, of the mould is removed and the core taken out, so that contraction may proceed until complete.

Fig. 6 represents a crank of very large dimensions. Difficulties arise in this case from the tendency to the formation of cavities in the lower web, *b*, owing to the absence of any connection between this and the upper web, *a*, except the pin, *c*. To obviate this defect, an auxiliary gate, h^1, must be arranged exactly underneath the main gates, *h*, the metal being poured through a separate gate, *g*, reaching down to the lower web of the crank, in order to secure more uniform distribution of the metal.

In the case of the cross-head, shown in Fig. 7, the difficulties are caused by the unequal thicknesses of the metal, the lower portion being very thin, whilst the upper part is thick, the result being a tendency to form fissures. To prevent this, the core, *a*, is made hollow, and is covered with only a thin layer of composition, in order that it may give when the metal begins to shrink. Round section cores should not be covered with more than about an inch of composition, the central portion being made of loam, as in the case of cores for grey iron.

Fig. 8 illustrates a mould and gates for a T-piece, the pouring gate, *a*, being employed for large castings, whilst for smaller work the metal may be poured through one of the risers. The latter are situated either on the flanges, as shown by *b* and *c*, or near by. In the former case, after the waste pieces have been sawn off horizontally, the flanges must be turned to remove the remnants, *x*. This operation may be



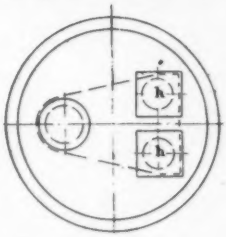


FIG. 6.

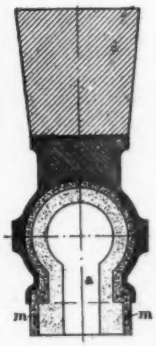


FIG. 7.

saved by arranging the gates by the side of the flanges, as at *d*.

It is well-known that the best way to obtain castings of compact structure is by top pouring, but in many instances this method is precluded by the shape of the castings, unless gates of special form are used. Fig 9, which represents a valve casing, may serve as a typical example. In order to obtain a firm flange, *a*, a separate gate must be provided, which is connected with the main gate by a runner, *b*.

Fig. 10 represents a traverse, cast in the floor. In consequence of the great weight of the casting (35 tons) and its considerable length (33 ft.), pouring from the two sides is essential, and, since the metal is relatively thin, the molten steel must be very hot and the pouring gates of large diameter, in order that the steel can run and join in the middle, as well as rise sufficiently to fill up all parts, even the thinnest, at once. The cores are surrounded by steel on almost every side, and therefore subjected to strong upward pressure, so that care must be taken to prevent their rising. The best means of accomplishing this object is by anchoring the cores, by means of tie bars with screw tops, as shown in Fig. 10. The gases liberated in pouring must be led away downward into the bed of coke underlying the whole of the piece. After pouring, the casting should be loosened, on account of the thinness of the metal. Contraction sets in in

the direction indicated by the arrow *a*, and, unless the sand be removed, the flanges are liable to develop cracks. This defect also becomes manifested in the corners, *b*. Stresses and cracks inside the traverse can be prevented by filling the centre of the core with a yielding bed of coke. The pouring gates are arranged in the same way as in the previous examples.

To prevent the formation of cavities in heavy pieces and those with local accumulations of metal, it is usual to cast steel and wrought iron parts into the mass, an example of which is shown in Fig. 11, representing a locomotive wheel with counterpoise. Here,

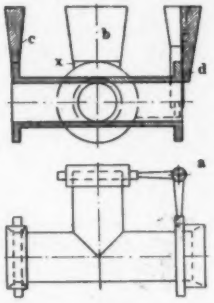


FIG. 8.

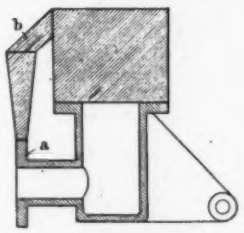


FIG. 9.

a, and *b*, are iron bars of square section, which must be arranged in the mould in such a manner that they will be surrounded on all sides by steel. The steel in the counterpoise solidifies almost immediately, so that no cavities can be formed; and owing to the insertion of the iron bars, gates of smaller dimensions can be used.

When the counterpoise is not very large, the inserted bars may be replaced by a thick underlay of iron plate (1½ to 2 in.) (indicated in the drawing by the surface, *c*), and brushed over with graphite to prevent the molten metal from sticking. The action of the plate is the same as that of the inserted bars, namely, to ensure more rapid cooling of the steel at that place.

The 2-ft. pulley illustrated in Fig. 12, has a number of nails, etc., cast in at the thick places, to prevent the formation of hollows. In order to keep the pieces from burning on to the mould after pouring, the surface of the mould should be carefully sleeked, to compress the superficial pores, and then faced with fire-proof material better able to stand heat than the moulding composition. Useful facing materials can be made from the following recipes:—

1. Graphite 4 parts, firebrick 1, finest clay 1 part.
2. Graphite 1 part, Dinas powder 1 part, the latter being mixed with dextrin before incorporation with the graphite.
3. Silicious sinter in dextrin solution.
4. Firebrick 5 parts, clay 1 part.
5. Graphite 12 parts, moulding compo. powder 4 parts; both in a finely ground state.

The firing of the moulds should be effected at a temperature of 400 to 500 C. The drying ovens are of various types, and are heated by ordinary flat grates,

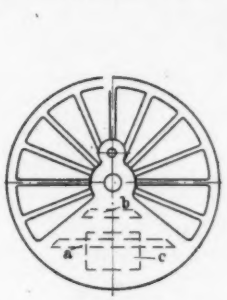


FIG. 11.

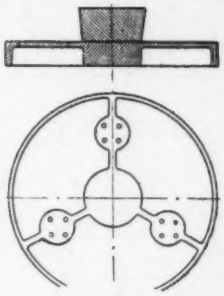


FIG. 12.

gas, or by combined methods. Coke is the usual fuel, coal or lignite being less frequently employed. It is advisable to keep the oven at a moderately low temperature at first, in order to facilitate the escape of the steam given off, and also to ensure uniform drying. As the liberation of steam diminishes, the temperature may be gradually raised, to the maximum of 400 to 500 C. The average time required for drying the moulds is 24 hours, though in very hot ovens, especially those heated by gas, from 12 to 18 hours, will be sufficient, whilst on the other hand, slow ovens will take 36 hours. When the drying proceeds quickly the surface of the mould gets covered with a hard crust, which cracks under the pressure of the water vapour expelled from the inner portions of the mould. The dried moulds must be sleeked over in all cases, it being impossible to entirely prevent the formation of cracks, even with the greatest care in drying. When this work is completed, the insertion of the cores and building up of the mould boxes are proceeded with.

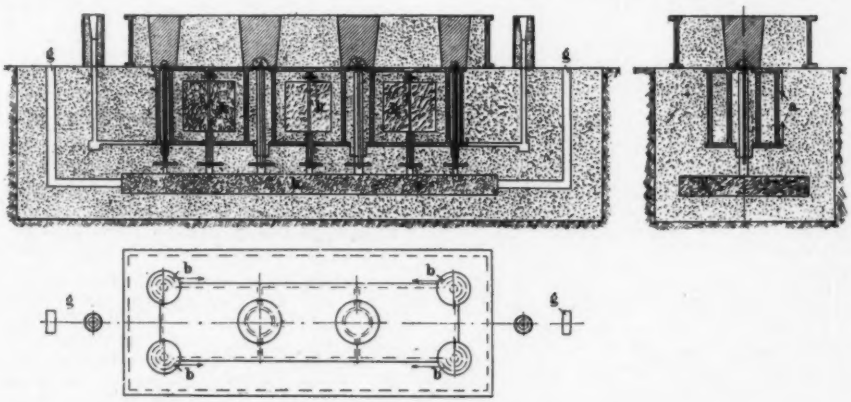


FIG. 10.

Composition moulds are not so sensitive to the in-

fluence of moisture as those made of moulding sand, and may be left for days without fear of any distortion of the pieces during casting. Nevertheless, cold and perhaps damp, moulds are attended with the drawback that a slight hardening of the surface of the steel may occur during pouring, and pores may easily be formed which are detrimental to pieces that are to be afterwards worked. Very thin castings require to be cast in hot moulds, as well as of very hot metal, in order that the latter may fill all parts of the mould completely.

Making and Pouring the Steel.

The composition and character of the steel are essential factors to the success of steel castings. In the first place, complete oxidation must be secured by additions of ferro-silicon, ferro-manganese, and aluminium. Unless this is effectually done, bubbles of gas will form in the steel during pouring, and castings exhibiting this defect are useless.

An important constituent of steel is carbon, the percentage of which rises to 0.6 to 1 per cent. for very hard products, such as parts for stamping mills, ore crushers, edge-runner mills, etc., whereas it should be much lower for constructional castings. The subjoined table gives the suitable percentages of carbon, silicon and manganese for the uses specified. The influence of carbon on the properties of steel may be taken as already known. The function of silicon is to neutralise the effect of carbon, to a certain extent, whereas manganese supplements it. Sulphur and phosphorus are the injurious elements in steel, and their proportions should therefore be kept as low as possible, to prevent the quality of the metal from being impaired.

Usual Composition of Steel for

	Carbon. Per cent.	Silicon. Per cent.	Manganese. Per cent.
Small machine parts	0.5	0.25	0.50
Large machine parts	0.1 to 0.4	0.2 to 0.4	0.5 to 0.8
Hard pieces for edge runners, ore crushers, &c.	0.8 to 1.0	0.2 to 0.4	0.5 to 1.0
Shipbuilding material (stem posts, rudder frames ...	0.2 to 0.4	0 3	0.5
Switches, press cylinders, &c.	0.7	0.4	0.8

The steel is produced in crucibles, open-hearth furnaces, and in the small converter, and, more recently, in the electric furnace.

The crucible is only used for small pieces and small quantities; mild steel, with less than 0.4 per cent. of carbon is difficult to melt in the crucible, owing to the high temperature required. Of late years, however, very mild steel is also made in crucibles heated by oil fuel, which enables the requisite temperature to be attained. Castings made in this way are known as Mitis castings.

The defects of the crucible furnace are as follows:—Since the metal can only be melted and not fined, it is necessary to use pure, and therefore expensive, raw material; the consumption of fuel is large, and the wages bill high. The advantages, on the other hand, are: uniform composition of the steel, and the certainty of producing castings free from bubbles.

The open-hearth furnace is used in steel foundries when a large output and heavy castings are in question. Furnaces holding from 3 to 30 tons are in use, the average size being 15 tons. The lining may be acid or basic, the former being cheaper, but requiring a purer raw material than the basic process. The popularity of the open-hearth furnace is due to the circumstance that the quality of the final product is not so greatly influenced by that of the raw material, owing to the possibility of eliminating the injurious elements during the process, which is therefore cheaper than the crucible process. The fuel and wages bills are also smaller. The chief defect of the open-hearth process is that it must be carried on continuously.

The small converter may be recommended for a medium output and castings of medium size. The converter will hold from 1 to 5 tons, the mean being 3 tons; and with this size, castings weighing about 4 to 4½ tons can be produced, two blows of the converter being, however, necessary. Acid lining is usually employed. The cost of production is lower than in the crucible process, but higher than in the open-hearth furnace, owing to the necessity for using purer and dearer raw material: pig-iron (hematite) high in silicon and low in sulphur and phosphorus. The depreciation is also a heavier item than with the open-hearth furnace. The advantage of the small converter is that it can be worked intermittently, according to the actual production required.

The induction furnace is useful for the production of castings of higher quality than can be obtained with any of the other processes mentioned. Owing to the perfect fining, and elimination of sulphur and phosphorus, the product is very pure, and, therefore, of excellent quality.

The pouring temperature of the steel has been mentioned already. After pouring, the gates require feeding up, especially in the case of heavy castings, in order to minimise the formation of hollows. As previously stated, castings, whose shape renders them liable to stresses and cracking, should be loosened from the moulds after pouring.

Annealing the Castings.

Loosening the mould will not always prevent the formation of cracks in castings, and these have to be annealed at 800 to 1,000 C. after cleaning, this treatment being also necessary to soften the outer surface a little, in order to facilitate subsequent working (sawing off the gates, and planing and turning the surfaces). Annealing is carried on mostly in furnaces with travelling hearths, as well as in annealing pits with removable vaulted covers. The furnaces are heated by flat grates or gas. Care should be taken when putting the castings into the furnace to place them so that the axial direction is parallel to that of the flame, since if they were laid at right angles to the latter, distortion would readily ensue. The operation takes 36 to 48 hours, and when finished, the castings are left to cool down in the furnace, so that the surfaces may not be hardened by cooling down too quickly, and the annealing process rendered nugatory. Trimming up the castings consists in removing the gates by means of cold-iron saws and on the lathe.

Causes of the Relatively High Cost of Steel Castings in comparison with Grey Iron Castings.

The high cost of steel castings is due to the steel itself, the moulding material, the expense of moulding, the drying of the moulds, the greater waste in gates, the annealing, and the trimming up. Latterly it has been found possible to reduce the cost by the use of green moulds, the material of which is cheaper, whilst the expense of drying is saved as well as the cost of conveying the moulds to and from the drying oven. This means a considerable saving in wages for labourers and moulders, the green moulds not needing to be sleeked. The percentage of waste castings is also reduced, since, owing to the yielding nature of the moulds, no stresses or cracks are set up in the castings.

Up to the present, the use of green sand moulds has been confined to small castings, such as wagon axles and truck wheels; but there is no doubt it can be extended to larger articles as well, and as the prime cost of steel castings is lessened thereby the demand for them will increase.—(Giesserei, Zeitung).

Machine Moulding of Bevel Gears.

By A. G.

The moulding of bevel gears by machine is done in order to ensure a nearer approach to accuracy of pitch and shape than is usually obtainable by the employment of a pattern. It is also adopted to save the cost of a full pattern. Though the expense of moulding is considerably increased, it does not reach that of a pattern. But if several of such moulds are required, the cost of these equals or exceeds that of a complete pattern, and then the question becomes one of relative degrees of accuracy, as well as of relative cost. Speaking generally, the place of machine-moulding is unassailable when massive articles that require facings, bosses, or other attachments in the top. These can be laid by measurement in their proper positions on the dummy mould, and the top be rammed over them with less trouble and risk than if measured and set directly into the top.

The same difficulty is met in machine work as in those moulded from patterns, due to the slight amount of bevel at the ends of the teeth as the wheels approach the crown form. Figs. 1 and 5 show alternative methods to adopt. In Fig. 1 the bevel is swept by the board, but in Figs. 3 and 4 a space is left between the joints struck by B and C equal to

FIG. 1.—BOARD STRIKING TOP PART UP DIRECTLY.

FIG. 2.—BOARD IN POSITION FOR STRIKING BOTTOM.

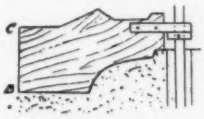


FIG. 3.—BOARD IN POSITION FOR STRIKING DUMMY TOP.

FIG. 4.—BOARD IN POSITION FOR STRIKING BOTTOM.

are in question. The patterns of these would not only be costly, but if made very accurately in the first place they would suffer distortion in time by usage. Having a true machine, with reasonable care in preparing the pattern parts and in moulding, any number of machine-made wheels will be practically alike. The rivalry of cut gears comes in chiefly in those of small and medium dimensions, and in those which are required in large quantities.

There are several ways by which bevel gears are moulded by machine, depending not only on the forms of the wheels, but also on the methods which exist in different shops.

But the essential parts required are striking or sweeping boards, tooth blocks, and core boxes, with the depth of the bevel, which is afterwards filled in with green sand cores of the thickness I, shown in section in the mould Fig. 5, the depth of which corresponds with the distance I in Fig. 2. The boards for the top and bottom may be made separately, or be combined in one, the latter having the advantage of keeping the boards for one wheel together, instead of them getting separated when stored away.

Tooth blocks vary but slightly, the principal difference found being in the number of teeth used, and in the method of cutting. From two to four teeth are employed. Two teeth mould one tooth space; three, two spaces. If the number of teeth be cut beyond two they must be cut most accurately, because not only have the tooth spaces to be considered, but

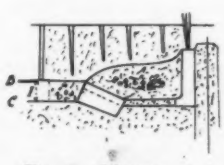


FIG. 5.—MOULD SECTION WITH RING OF CORES.

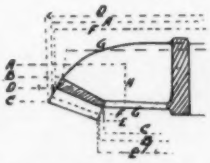


FIG. 6.—DIAGRAM FOR MAKING TOOTH BLOCK.

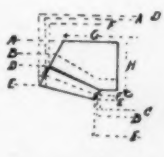


FIG. 7.—DIAGRAM FOR TOOTH BLOCK.

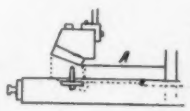


FIG. 8.—SETTING OF BLOCK.

sundry adjuncts, each of which is subject to variations. The function of striking boards is to sweep up a bed for the teeth and cores, and to form the cope or top part. The general shape of the boards is shown in Figs. 1 and 2, the board cut for the top striking the top part direct, which in that case has to be turned over subsequently in loam mould fashion. An alternative to this is to strike a dummy mould (Fig. 3), and ram the top on that in green sand fashion. The advantage of the latter is that there is no risk of the top and bottom not matching, and that no check is necessary for jointing, as there is in the former, provided the bottom is moulded in the floor. It is a method admirably suited for large wheels bedded in the floor, and for any wheels or rings the teeth and their pitch must match absolutely. The sectional form of the block is that of the teeth and their faces only, since the rim and the remainder of the wheel are swept by the boards, or formed by cores. The hinder portion and top of the block have no formative function, but must be cut in horizontal and perpendicular planes.

Since the block forms a section of the wheel teeth these are marked out precisely as though a segment were cut out of a wheel rim, but neglecting, of course, as just noted, the interior portions of the rim. Figs. 6 and 7 illustrate this, the section of the tooth block being shown in relation to the section of the wheel rim; and radial and gauged lines being drawn on each in corresponding positions, rendering

the drawings self-explanatory. In the plan the pitch and bevel of the tooth flanks are obtained from a centre line drawn across the block. A commencement is made with a block of cubical shape. The teeth are variously formed. They are cut from the solid, the grain running in the same direction as the length of the teeth; or they are glued on a separate block or backing; or they may be dovetailed in the

FIG. 9.—BLOCK IN POSITION FOR MOULDING.

body block in a single piece, which permits of the small fillets being cut in their roots. They are shaped with gouge, chisel, and planes. or they can be planed out in a bevel gear planer, when such a machine is available. Fig. 8 illustrates the gauging of the radial distance of a bevel tooth block, with the radius strip A set between the post of the machine, and the point of the tooth on the small diameter.

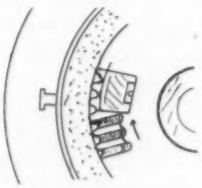


FIG. 10.—MOULDED TEETH.

FIG. 11.—CORE RAMMED IN BOX.

In Fig. 9 the block has been lowered into position in readiness for ramming. In Fig. 10 a few teeth have been rammed, and the block has been moved round into a fresh position in the direction of the arrow. The core boxes (Fig. 11) for bevel gears are, as a rule, made to suit arms only. If a wheel has a plated centre, that is made by sweeping up with boards, which form the outlines of the toothed rim. The cores form the space between the top and the bottom of the mould as swept by the boards (Fig. 12), which represents the mould commenced by the board (Figs. 1 and 2). They are simply laid in place by measurement, the thickness of the arm and rim spaces being taken by means of thickness strips of wood. The pressure of the top on the cores is usually sufficient to retain them in their place.

If they are shallow their security is often ensured by pushing a spike through them into the mould below. Core vents are generally brought out at the top. The cores are rammed on grids with eyes to permit them being lifted about. (See Figs. 11 and 12.)

The foregoing is a concise description of the work involved in a plain wheel. Variations are numerous. Casting friction collars at the end of the teeth does not affect the tooth block, but only the striking boards; or, in many cases, a ring core, or segmental

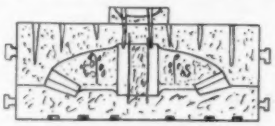


FIG. 12.—MOULD OF WHEEL COMPLETED.

FIG. 13.

cores may be made to form the collar. In the case of smaller pinions blocks may be dispensed with by making a block exactly like a blank coming to the tooth points, and ramming this up in the mould instead of striking up Fig. 13. A hole is bored in the block to permit it to slip over the machine centre bar. Numerous attachments are cast to wheels, such as other wheels, pinions, long bosses and sleeves, brake rings, etc. These are either swept up or made as separate pattern parts and bedded in. If two wheels are cast together they are moulded separately and centred subsequently. In other work swept up or made from complete pattern parts, exact centreing is necessary. Sweeping boards attached to the same machine bar or wheel boards ensure this. In the case of such pattern parts as clutches and bosses, these are centred by boring holes in them to fit over the machine bar. (See Fig. 13.)

HEMATITE IRON IN 1908.—In their annual report on West Coast hematite pig-iron, Messrs. R. Feldtmann & Company, of Glasgow, state that the make of hematite iron and spiegel amounted in 1908 to 1,016,000 tons, a decrease of 293,583 tons compared with 1907. The average make per furnace was about 888 tons per week, against 821 tons in 1907.

	Tons.
Stocks at end of 1907	36,242
Production during 1908	1,016,000
	1,052,242
Stocks at end of 1908	75,256
Consumption and Shipments during 1908 ...	976,986
" " " 1907 ...	1,374,391
Decrease	397,405

The decrease is accounted for by a reduction in shipments of 143,912 tons, and in inland consumption of 253,493 tons. The lowest price was 56s. 9d. in August, against 66s. in December, 1907; the highest price was 65s. 4½d. in January, against 80s. 9d. in May, 1907; and the price at the end of the year was 57s. 6d. against 66s. in the previous year.

	Tons.	Increase or decrease compared with 1907. Tons.
Total stock in makers' hands and in public stores	75,256	increase 39,014
Foreign shipment of hematite iron ...	56,129	decrease 12,156
Coastwise shipment of hematite iron ...	208,211	decrease 131,756
Foreign shipments of steel	52,600	decrease 39,920
Coastwise shipments of steel	180,284	decrease 131,860
Deliveries locally and export by rail, iron	712,646	decrease 253,493

A LOW BRASS MIXTURE.—The following mixture will give the greenish-yellow colour which is often desired in such castings as candlesticks and other ornamental work, and is a characteristic of what is known as low brass":—

	Per cent.
Copper	75
Spelter	22
Lead	2
Tin	1

Foundry Tests for Pig-Iron.

British Foundrymen's Association: Lancashire Branch.

The monthly meeting of this Branch was held in the School of Technology, Manchester, on Saturday, January 16, Mr. R. W. Kenyon presiding. An interesting practical paper on "Foundry Tests for Pig-iron" was given by Mr. F. J. Cook, of Birmingham (President of the Parent Body).

At the outset Mr. Cook referred to the old methods of judging the quality of pig-irons by their relative breaking properites, appearance of the fracture, and other tests of a rough-and-ready character. He expressed the opinion that pig-irons were more uniform in character when blast furnaces were driven under less strenuous conditions than at present prevail. When chemical analysis was first resorted to by foundrymen, it was asserted to be the cure for all their iron troubles, but while giving valuable indications of the character of the metal, there were always difficulties arising of a physical nature of which chemical analysis gave no indication.

As an example, a wedge, 3 ft. long and 6 in. square at the base and tapering to a point at the other end, while showing practically the same chemical analysis in all parts of the casting, was totally different in its physical characteristics, varying from an open grey iron at the base to a white iron at the thin end.

The temperature of tapping the iron from the blast furnace had a great effect on the physical condition of the resulting pig, while the rate of cooling was another important factor. Mr. Cook then dealt with the various types of testing machine, and pointed out the want of a reliable machine that would give records of tests mechanically without relying on the more or less careful manipulation of the operator. In making tests he advised the use of one size of test bar, making it a standard.

The question of cupola blast pressure was then dealt with, in connection with which records taken by a Bristol recorder were shown. The difference in qualities of iron of similar character and melted in the same furnace under different blast pressures was most marked. With a pressure of 9 ozs. the hardness was 48, 12 ozs. 50, 13 ozs. 58, 14 ozs. 60, 17 ozs. 78, the varying hardness being entirely due to difference in blast pressure. This fact was of value to the foundryman, as it was possible to vary the character of the iron to suit light and heavy castings by means of the blast without alterations to the furnace charges.

The shrinkage of iron was also discussed, the lecturer showing that by the use of a test bar having the shape of a K with the sharp angles rounded, the liability of an iron to excessive shrinkage was shown in a marked degree. When broken up the heaviest part of a K-bar would be quite spongy if the shrinkage was excessive. Personally, he had these bars cast every day, a boy making the mould and the furnaceman casting it at the proper time.

The effect of sulphur on foundry iron was also dealt with, and Mr. Cook showed prints of the sections of pig-iron where the position of the sulphur was altered by the casting temperature, the sulphide being nearer the surface of the pigs cast at the higher temperatures. The lecture was illustrated by lantern slides and specimens, while sulphur prints of various pig-irons were also taken.

Discussion.

Mr. Kenyon, opening the discussion on the lecture, said he had come to the conclusion that they would have to have a blast-pressure recorder fixed to their cupolas.

Mr. W. H. Sherburn thought there were three factors necessary in modern foundry practice. In addition to the chemical and physical tests there was the experience of the practical man. We know of men who, though without technical knowledge, but having grown in the foundry, seemed to understand intuitively what was wrong when difficulties arose, and were able to remove the trouble with remarkable success.

Another member asked how Mr. Cook arranged for the alteration of the blast pressure, and when he would expect to get the iron down at the right time?

Mr. Cook, in reply, referring to altering blast pressure, said their blower was driven electrically, and by means of a switch the speed could be varied. Generally, he arranged to cast all heavy work during the same blow, but in the event of casting heavy and light work on the same blow he would blow at high pressure for the heavy casting first, and then lower the blast pressure for the softer iron required for the lighter castings.

A NUMBER of representative Manchester engineering firms were present on Thursday, January 14, at the Midland Hotel to discuss the desirability of holding a general engineering exhibition in that city in the year 1910. The meeting was called by the International Trade Exhibitions, Limited, of Broad Street, House, London, E.C., who were the organising managers of the recent electrical exhibition held in Manchester, and the suggestion made by this company was that the Exhibition, should it take place, should be promoted by a committee appointed by the industry, representing the various sections of the engineering trades and representatives of engineering institutions, who should be the virtual proprietors of the undertaking, and who should have full conduct of the exhibition, employing the company as organising managers and business contractors. The meeting was entirely favourable to such an exhibition being held, and a provisional committee of nine engineering firms, representing different sections, was appointed. A further meeting was arranged at the Midland Hotel, Manchester, on February 17 next, with a view to inviting representatives from the whole of the engineering trade to be present.

MR. DOUGLAS GORDON, who has been manager of an American engineering company for a number of years, is making arrangements to establish himself in London in the course of two or three months. He is at present making arrangements to represent several American engineering firms in Great Britain.

THE COURT OF ARBITRATION FOR INDUSTRIAL DISPUTES.

The Board of Trade have issued certain regulations to be observed in connection with the Courts of Arbitration for the settlement of industrial disputes. The regulations deal with the procedure to be followed in respect of applications to the Board of Trade for the appointment of Courts of Arbitration, and with certain matters relating to the business of the Courts. When both parties to an industrial dispute desire to have their differences settled by arbitration it is open to them jointly to apply to the Board of Trade under the Conciliation Act either (1) for the appointment of a single arbitrator, or (2) for the appointment of a Court of Arbitration in accordance with the scheme devised in 1908 by the President of the Board of Trade. The following are the regulations referred to:—

(1.) The application should state:—(*a*) The subject-matter of the dispute; (*b*) whether the parties wish the Court to consist of (1) a chairman and two arbitrators, or (2) a chairman and four arbitrators; (*c*) whether the parties desire the Board of Trade (i.) to appoint a chairman and arbitrators all of whose names have been jointly selected by the parties from the respective panels, or (ii.) to appoint a chairman whose name has been jointly selected by the parties from the chairmen's panel, and to select and appoint the arbitrators from the respective panels, or (iii.) to select and appoint the chairman from the chairmen's panel, and to appoint arbitrators jointly selected by the parties from the respective panels, or (iv.) to select and appoint all the members of the Court from the respective panels; (*d*) whether the parties wish the Court to appoint, or apply to the Board of Trade to appoint, a technical assessor or assessors.

(3.) A Court of Arbitration shall, if either party or both parties shall have so requested, or may on their own initiative, appoint or apply to the Board of Trade to appoint a technical assessor or assessors.

(4.) Technical assessors shall not be members of the Court. They will be appointed solely for the purpose of giving the Court information on technical matters when required by them. They will only be entitled to be present at such stages of the proceedings as the Court may direct. Every assessor before taking up his duties shall pledge himself in writing to keep secret all matters with which he shall in the course of the performance of such duties become acquainted.

(5.) All procedure in connection with the hearing of a case shall be settled by the Chairman after consultation with other members of the Court, including the mode of appearance thereat. For the convenience of the Court, each application should be accompanied by a statement showing (*a*) whom the parties desire to represent them at the hearing (whether counsel, solicitor, secretary of the Association or Trade Union involved, etc.), and (*b*) the approximate number of witnesses each side desires to call.

(6.) The award of a majority of the members of the Court shall be the award of the Court. When no majority can be obtained in favour of an award, owing to the arbitrators being equally divided, then the matter shall be decided by the Chairman.

(7.) After an award is made, it shall be signed by the Chairman on behalf of the Court, and he shall then cause a copy to be sent to the representatives of both parties to the dispute. The original award, together with any shorthand notes and all relevant papers, shall be forwarded to the Board of Trade.

(8.) Shorthand notes shall only be paid for by the Board of Trade if the Chairman of the Court certifies that the notes were necessary for the purpose of the Court. The Board of Trade will also pay any expenses connected with the drawing of the award, and for the hire of a room for the hearing of the case when necessary. They will also pay the expenses of the members of the Court.

"FAIR WAGES" IN GOVERNMENT CONTRACTS.

As long ago as 1891 the House of Commons passed a resolution aiming at (1) the prevention of the evils disclosed before the Sweating Committee; (2) the prevention of abuse arising from sub-letting; and (3) the payment of current rates of wages. In August, 1907, a Departmental Committee was appointed to consider the working of this resolution as embodied in Government contracts, and the Commission have now issued their report. The conclusions arrived at are summarised as follows:—

(*a*) We recommend that the present wording of the Fair Wages Clause, which obliges the contractor to pay the current rates of wages for competent workmen in the district where the work is carried out, should be retained.

(*b*) While we do not recommend that words intended to enforce the observance of "Trade Union conditions" should be inserted in Government contracts, we think that such conditions of employment as are generally accepted in the district, in the trade concerned, must be taken into account when considering the question whether a particular contractor is observing the Fair Wages Clauses.

(*c*) We think that where persons are employed at piece rates of wages on work for which a current time rate exists, the general principle that the piece work earnings for a given period should exceed the standard time wages for the same period on similar work should be recognised.

(*d*) In the case of trades in which the Department concerned considers that difficulties are likely to arise in ascertaining the "current rates of wages," the following recommendations are made:—(1) That the Government should fix in the contract the rates of wages to be paid to the various classes of workpeople engaged. (2) That a minimum time rate of wages should be fixed. (3) That wages in trades such as those in question should be dealt with by Wages Boards. (4) That the contractor should be required, when tendering, to furnish a schedule of the rates of wages and hours of labour which he proposes to pay.

(*e*) We cannot recommend that Government contracts should be restricted to what are known technically as "fair houses," but we think that great care should continue to be taken in selecting firms to be placed on the list of contractors.

(*f*) We recommend that in all works where Government contracts are being executed, a copy of all the labour conditions of the contracts should be prominently exhibited.

(*g*) We recommend that, so far as practicable and at the discretion of the Departments concerned, the names and addresses of all firms obtaining Government contracts should be published in the "Board of Trade Journal" or "Board of Trade Labour Gazette."

(*h*) We recommend that there should be uniformity among the Departments in the wording of all clauses dealing with the conditions of labour in contracts affecting the same trades.

(*i*) We think that every effort should be made to ensure all possible co-operation among the different contracting Departments in such matters as inspection, the investigation of complaints, and the interpretation of the Fair Wages Clauses in difficult cases. With a view to furthering this object we suggest that a committee should be formed of representatives of the different Contracting Departments, who should meet from time to time for the discussion of matters of common interest

Electric Furnaces for Steel.*

The following tables summarise the present position of the manufacture of steel by the electric process. It will be seen that the tables classify the works at which electric furnaces are being used, and give their capacity, type and size:—

Works.	At work.	Out of work.	Under construction.	Current.	Size.
	Charge in Kilos.				
KJELLIN.	**Induction Furnaces.**				
Röchlingsche Eisen- und Stahlwerke, Völklingen (Germany)	,,	8,500	,,	Single-phase	750 kw.
Fried. Krupp A.-G., Essen (Germany)	8,500	,,	,,	—	750 kw.
Oberschlesische Eisenindustrie-A.-G., Gleiwitz (Germany)	1,500	,,	,,	—	180 kw.
Poldihütte, Kladno (Bohemia)	4,000	,,	,,	—	440 kw.
J. Brauns' Söhne, Vöcklabruck (Austria)	400	,,	,,	—	65 kw.
Allg. Calciumcarbide-Genossenschaft Gurtnellen (Switzerland)	,,	?	,,	—	330 kw.
Vidua de Urigoitia à Hijà Araya (Spain)	1,500	,,	,,	—	215 kw.
Alti Forni Gregorini, Lovere (Italy)	,,	,,	1,500	—	330 kw.
Eisenwerk Domnarfvet, † Gysinge (Sweden)	1,500	,,	,,	—	175 kw.
Metallurgiska, Aktiebolaget, Trollhättan (Sweden)	,,	,,	2,000	—	300 kw.
Vickers, Sons, & Maxim, Sheffield	550	,,	,,	—	150 kw.
Gröndal-Kjellin Co., Nine Elms Lane, London	100	,,	,,	—	60 kw.
American Electric Furnace Co., Niagara Falls (U.S.A.)	800	,,	,,	—	150 kw.
,,	100	,,	,,	—	60 kw.
RÖCHLING RODENHAUSER.					
Röchlingsche Eisen- und Stahlwerke, Völklingen (Germany)	3,500	,,	,,	—	400 kw.*a*
,,	,,	,,	8,500	—	750 kw.*a*
,,	2,000	,,	,,	3-phase	275 kw.*a*
Bergische Stahlindustrie, Remscheid (Germany)	,,	,,	5,000	Single-phase	500 kw.
Le Gallais, Metz & Co., Dommeldingen (Luxembourg)	700	,,	,,	—	100 kw.*b*
,,	,,	,,	3,500	—	300 kw.*c*
,,	,,	,,	3,500	—	300 kw.*c*
,,	,,	,,	1,500	3-phase	275 kw.*d*
Aciéries Liégoises, Bressoux-les-Liège (Belgium)	,,	,,	1 000	3-phase	200 kw.*e*
J. Knöpfel, Walzenhausen (Switzerland)	,,	,,	1,000	3-phase	175 kw.*e*
SCHNEIDER.					
Schneider & Co., Creusot (France)	1,000	..	..		Experimental.
SCHNEIDER GIN.					
? Plettenberg (Germany)	?	?	4,500	Single-phase	400 kw.
COLBY.					
H. Disston & Sons, Philadelphia (U.S.A.)	90	—	—	Single-phase	
FRICK.					
Fried. Krupp A.-G. (Germany)	10 000	—	—	—	750 kw.
John Brown & Co., Sheffield	1,800	—	—	—	200 kw.
Wm. Jessop & Sons, Sheffield	—	3,000	—	—	450 kw.

* "Stahl und Eisen." † Size and number not yet determined.

Works.	At work.	Out of work.	Under construction.	Current.	Size.
	Charge in Kilos.				
A.-G. ELECTROMETALL, LUDVIKA (SWEDEN).	**Induction Furnaces** (*cont.*).				
Arvika (Sweden)	1,000	—	—	3-phase	175 kw.*f*
Hagfors (Sweden)	—	—	500	,,	125 kw.
St. John del Rey Mining Co. (Brazil).	—	—	2,000	—	300 kw.
HÉROULT.	**Arc Furnaces.**				
Edgar Allen & Co., Sheffield	—	—	3,000	Single-phase	
,,	—	—	†		
Stahlwerke Richard Lindenberg A.-G., Remscheid-Hasten (Germany)	3,000	—	—		370 kw.*g*
,,	1,800	—	—		300 kw.*g*
,,	500	—	—		
Bismarckhütte, Bismarckhütte (Germany)	3,000	—	—		400 kw.*h*
,,	1,000	—	—		260 kw.*h*
,,	—	—	†		
Deutsch-Oesterreichische Mannesmannröhren-Werke, Burbach (Germany)	—	—	3,000		400 kw.*i*
Deutsche Mannesmann-Röhren Werke, Saarbrücken (Germany).	—	—	†		
Danner & Co., Judenburg (Austria)	2,000	—	—		300 kw.*j*
Gebr. Bohler & Cie., A.-G., Kapfenberg (Austria)	2,500	—	—		350 kw.*j*
,,	—	—	†		
Georg. Fischer, Schaffhausen (Switzerland)	1,000	—	—		250 kw.*k*
,,	—	—	5,000		,,
,,	—	—	5,000		,,
Kaernthner Eisen & Stahl Werke (Austria)	—	—	†		
Soc. Electromét Française, La Praz (France)	3,000	—	—		370 kw.*l*
Aciéries du Saut du Tarn, St. Juéry (France)	5,000	—	—		600 kw.*l*
Aktiebolaget Héroults Electriska Stal, Kortfors (Sweden)	4,500	—	—		300 kw.
Halcomb & Co., Syracuse (U.S.A.)	5,000	—	—		
The Nolde Electric Co., Baird (U.S.A.).	5,000	—	—		
The Firth Sterling Steel Co., McKeesport (U.S.A.)	3,000	—	—		
ocietà Tubi Mannesmann, Dalmine (Italy)	—	—	6,000		736 kw.*m*
,,	—	—	6,000		736 kw.*m*
DU GIFFRE.					
Soc. des Hauts-fourneaux et Forges, Allevard (France)	3,200	—	—	—	500 kw.
,,	3,200	—	—	—	500 kw.
GIROD.					
S.A. Electrometallurg. Procédés P. Girod, Ugine (France)	1,800	—	—	Single phase	300 kw.*n*
,,	—	—	2,000	,,	300 kw.*n*
,,	—	—	2,000	,,	300 kw.*n*
,,	—	—	8 to 10.000	,,	1,200 kw., 4 electrodes
,,	—	—	8 to 10,000	—	1,200 kw., 4 electrodes
Oehler & Co., Aarau (Switzerland)	2,000	—	—	,,	300 kw.*n*
Joh. Cockerill, Seraing (Belgium)	—	—	3 to 4,000	,,	450 kw.*n*
A. Stotz, Stuttgart-Kornwestheim (Germany)	—	—	2,000	,,	300 kw.*n*
Marrel Frères, Rive de Gier (France)	—	—	?	,,	
Ternitzer Eisen- und Stahlwerke, Ternitz (Austria)	—	—	?	,,	—

Works.	At work.	Out of work.	Under construction.	Current.	Size.
	Charge in Kilos.				
STASSANO.	**Arc Furnaces** (*cont.*)				
Bonner Fräserfabrik, G. m. b. H. Bonn (Germany)	1,000	—	—	3-phase	185 kw.*o*
,,	—	—	1,000	,,	,,
Forni Termoelettrici Stassano, Turin (Italy)	5,000	—	—	,,	750 kw.*o*
,,	5,000	—	—	,,	750 kw.*o*
,,	900	—	—	,,	180 kw.*o*
,,	900	—	—	,,	180 kw.*o*
,,	—	—	900	,,	180 kw.*o*
,,	400	—	—	,,	75 kw.*o*
,,	400	—	—	,,	,,
Royal Arsenal, Turin (Italy)	700	—	—	,,	150 k.w.*p*
,,	—	—	700	,,	,, *p*
KELLER.					
Holtzer & Co., Unieux (France)	8,000	—	—	—	*q*

The above tables show that, excluding the Wallin and the Hiorth designs, of which no particulars are available, the number of furnaces, either in operation or under construction, may be summarised as follows: —

	Induction.	Arc.
In operation	21	25
Under construction	12	19
	33	44

The number of furnaces of each type is as follows: —

Colby	1	Girod	10	Röchling R ...	10
Electrometal ...	3	Héroult ...	20	Schneider ...	1
Frick	3	Keller	1	Gin	1
Du Giffre ..	2	Kjellin	14	Stassano ...	11

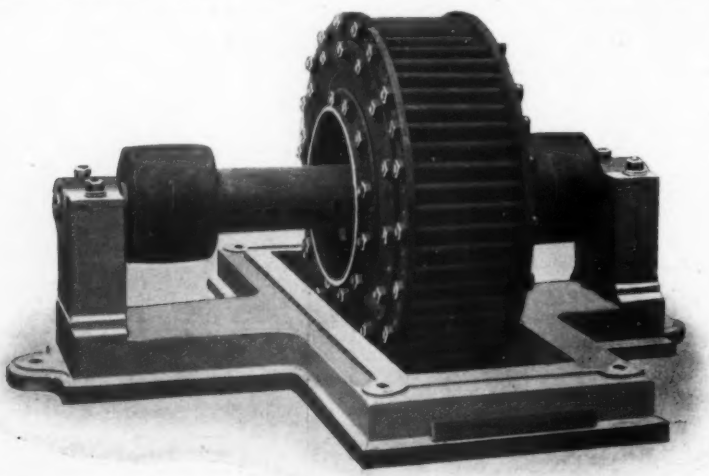
a Charge of liquid basic steel for special steels and rails. *b* Charge of liquid pig, ultimately from 3½-ton steel furnace. *c* Charge of liquid pig. *d* Charge of liquid steel from 3½-ton steel furnace. *e* Charge of cold pig for steel castings. *f* Malleable iron. *g* Charge of liquid steel from 8-ton open-hearth furnace for tool steels. *h* For tool steels or special steels. *i* Charge of liquid open-hearth steel for weldless tubes. *j* Charge of liquid open-hearth steel for tool steels. *k* Cold charge for castings. *l* Cold charge. *m* Cold charge for weldless tubes. *n* All these take a cold charge and make either castings or special steels. *o* These are for special steels and castings. *p* For projectile steel. *q* Charge of liquid steel.

An Improved Sand Mixer and Grinder.

The importance of the proper selection of sands and the thorough mixing, grinding, and screening of them is well recognised. Several machines have been constructed for the work of opening out and kneading the sand, but many of them require to be assisted by the use of auxiliary machines in preparing the various grades of sand.

In the "Eclipse" sand mixer, which is illustrated herewith, the desired result has been obtained, the machine fulfilling all conditions of general foundry requirements for thoroughly preparing the sand, loam, core sands, and materials at a small cost per ton.

The principle of the mixer is a combination of centrifugal force and gradual mixing and kneading of the particles together by four sets of revolving grids or steel bars held securely together by steel rings, the grids becoming finer in pitch as they near the periphery. They revolve in an opposite direction upon sleeves carrying pulleys secured thereto, which revolve upon a stationary steel spindle by means of patent oilless and frictionless bushes. The whole is mounted on a cast-iron bedplate supporting the steel spindle in brackets secured thereon. A steel cover encircles the whole of the working parts, keeping the machine perfectly dust-tight, and supporting a large feed hopper from which the materials pass into the centre of the machine, hence, through the rapidly revolving bars where it is mixed and delivered under the machine ready for use.



SHOWING THE ARRANGEMENT OF THE "ECLIPSE" SAND MIXER AND GRINDER.

The machine, which is 27 in. diameter, has a capacity of 3 to 4 tons per hour of damp sand, and about 2 tons per hour of loam, etc. The machine is made by Hall's Engineering Company, Hounds Gate Buildings, Nottingham.

The "Foundry Trade Journal" Bookshelf.

Alloys and Their Industrial Appliances.

By Edward T. Law. London; Charles Griffin & Company, Limited, Exeter Street, Strand, W.C.

It has often been a matter of especial regret to the many admirers of the late Sir W. C. Roberts-Austen that his untimely death deprived the industrial world of that comprehensive treatise on the subject of alloys which he would have been certain to produce had he been spared, and which, in fact, it is known he had in active preparation when stricken by his last illness. Mr. Law mentions the fact that seven years ago Sir W. C. Roberts-Austen asked him to assist in the preparation of such a work, and after his demise it was at first hoped that it might be finished, but unfortunately the available material proved inadequate. During recent years a great amount of research work has been undertaken with a view to determining the nature and physical properties of alloys, but much of it has been of a character interesting only to the scientific man and not calculated to appeal to the manufacturer. With this in mind Mr. Law has attempted, first, to summarise the existing state of our knowledge of mixed metals, paying special attention to general principles and essential facts, rather than to smaller details of less importance. Further, he has applied that knowledge to the industrial alloys in every-day use. His method of treatment is concise and practical, and the value of the work is rather enhanced than otherwise by the absence of highly scientific detail. A special feature of the book are the freezing point curves and the photo-micrographs, which are abundantly used to illustrate it, and in this connection it is interesting to note that the curves have been entirely replotted to one uniform scale, being thus strictly comparable. The photo-micrographs also are in most cases magnified 100 or 1,000 diameters, the samples being commercial alloys, and not small laboratory specimens. The value of these features will be readily appreciated, for confusion is often caused by the lack of a definite standard for curves and magnifications. Having placed his work on such a solid basis, the author proceeds to deal with the properties of alloys, methods of investigation, the constitution of alloys, and the influence of temperature on their properties. Following this, different chapters treat with the various copper, German silver, white metal, lead, tin, and antimony alloys, anti-friction metals, and aluminium alloys. Alloys of steel naturally receive considerable attention, the use of nickel, tungsten, manganese, chromium, etc., coming under review. In short, the author has condensed a valuable amount of information into a volume that will be appreciated by student and manufacturer alike.

The Abbott Versimetric Chart (Adelphi Series) No. IX.—Anthropometric (Weight).

Prepared by T. W. Abbot, and published by A. Couchman, The Medical Agency, Watergate House, 15, York Buildings, Adelphi, W.C.

This chart is designed for the ready and easy conversion of metrical weights and measures into their equivalent British denominations and *vice versâ*. The method is simple and ingenious, the scope of the chart ranging from 28 lbs. to 168 lbs. in British measure, and 12.7 to 76.2 kilogrammes in metric.

Book-keeping Down-to-Date.

By Andrew Munro. Elementary Edition. London: Effingham Wilson, 54, Threadneedle Street; Glasgow: W. & R. Holmes, 3, Dunlop Street.

For this little work the student is indebted to the success attending the author's treatise on book-keeping, in which the treatment of the subject is of a more advanced character. This volume is designed for the use of beginners, the author assuming an absence of any knowledge of the subject. A great variety of exercises are given, and without being discussive the author has continued to give a very full and practical explanation of the elements of book-keeping science.

ANNUALS.

Business Prospects Year Book, 1909.

Edited by Joseph Davies and C. P. Hailey. London: The Commercial Intelligence Publishing Company, Limited, 166, Fleet Street. Cardiff: The Business Statistics Publishing Company, 12, James Street.

The third annual issue of this Year Book follows the lines of its predecessors in presenting a forecast of the trade movements in the chief sections of commerce during the ensuing year. The publication of such forecasts is apt to strike the reader as a somewhat daring venture. The editors claim, however, that they are based on a careful analysis of public statistics and other facts available, and that the compilation of the work on these lines is justified by the success which has attended the previous issues.

Pig-Iron Statistics.

Compiled and published by E. W. Crawley, 14, Park Row, Leeds.

The twenty-seventh edition of this pocket annual appears in the familiar form of its predecessors. It presents statistics as to the prices, production, shipments, etc., of Scotch, Cleveland, and hematite pig-iron for a series of years; also the highest and lowest prices of copper and tin. Tables are added showing the daily prices of the three brands of pig-iron named, during 1907 and 1908.

Fowler's Mechanics' and Machinists' Pocket-Book and Diary, 1909.

Edited by William H. Fowler, M.I.Mech.E., etc. Manchester: Scientific Publishing Company.

The object of this addition to the list of engineering pocket books is to provide a synopsis of practical rules for fitters, turners, mill-wrights, pattern-makers, foundrymen, draughtsmen, and apprentices, etc., at a popular price. It is certainly one of the most comprehensive of its kind that we remember seeing. The information given is of an up-to-date character, and the matter relating to the various subjects treated has been conveniently grouped into sections to facilitate the task of reference.

UNITED ENGINEERING AND FOUNDRY COMPANY, Pittsburg, U.S.A. From this firm we have received a voluminous catalogue of rolling mill machinery giving particulars with illustrations of the latest designs in American practice.

INVENTIONS.

Applications for Patents.

—o—

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

—o—

1908.

27,134.*Indicating apparatus for furnaces. A. Lomschakow.
27,221. Metal alloy and its production. R. B. Wheatley, 115, Hungerford Road, Camden Road, London.
27,675.*Furnaces, kilns, etc. E. Schmatolla.
27,954. Welding expensive steels to cheaper varieties of steel or iron by oxy-acetylene blowpipe. E. R. Morrison, "Ashleigh," Elmfield Park, Gosforth, Newcastle-on-Tyne.
28,260. Casting steel ingots. N. Kostileff.
28,280.*Forming a casting mould. L. J. Wing, 1, Queen Victoria Street, London.

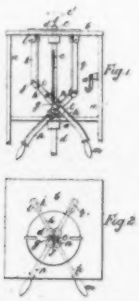
1909.

285. Electric furnaces. F. J. Bingham.
1339. Aluminium alloys. E. J. de St. Laurent, E. W. Lancaster, H. T. McNeale, and J. W. Collins, 2, Norfolk Street, Strand, London.
1365. German silver. W. R. Barclay and J. Rodgers, 24, Norfok Row, Sheffield.

Abstracts of British Patent Specifications recently accepted.

—o—

26,877 (1907). *Core Making and Sand Moulding Machines.*—F. Penlington, foundry superintendent, of 18, Station Road, Gorton, Manchester. The invention consists essentially in the provision of a moveable vent wire with a longitudinally moveable plunger, each adapted to be longitudinally adjusted and operated in



CORE-MAKING AND SAND MOULDING MACHINES.

accordance with the work in hand; slotted levers embracing the rod and plunger and links connected with the levers for directly operating such parts, similar mechanism with slight modifications being applied and essentially claimed in connection with the operation of one or a pair of tables in a sand-moulding machine. The invention particularly relates to that class of core-making machine in which dies or blocks are employed in which to ram the sand, and to that class of moulding machine in which a table, or tables, is employed and adapted to rise and fall. Fig. 1 indicates a front elevation of so much of a core-making machine, with the improvements applied thereto, as is necessary to enable the invention to be understood. Fig. 2 is a plan of same.

DEATHS.

—o—

MR. W. HELLEWELL, managing director of Marsden's Engines, Limited, of Queen Street, Heckmondwike, died recently.

MR. FRANK TAYLOR, head of the Sandycroft Foundry Company, and also of John Taylor & Sons, civil and mining engineers, Queen Street Place, London, E.C., died recently, aged 59 years.

THE death took place of Colonel Joseph B. Cochrane, V.D., recently, at his residence, Pedmore Hall, near Stourbridge, after a prolonged illness. The late Colonel Cochrane was the son of the late Alexander Brodie Cochrane, who lived at "The Heath," Stourbridge, and came of an old Scottish family. The Cochranes have long held honoured names in the iron trade of the country, not only in the Midlands, but in the North as well. The late Colonel Cochrane was the principal of the Woodside Iron Works, near Dudley.

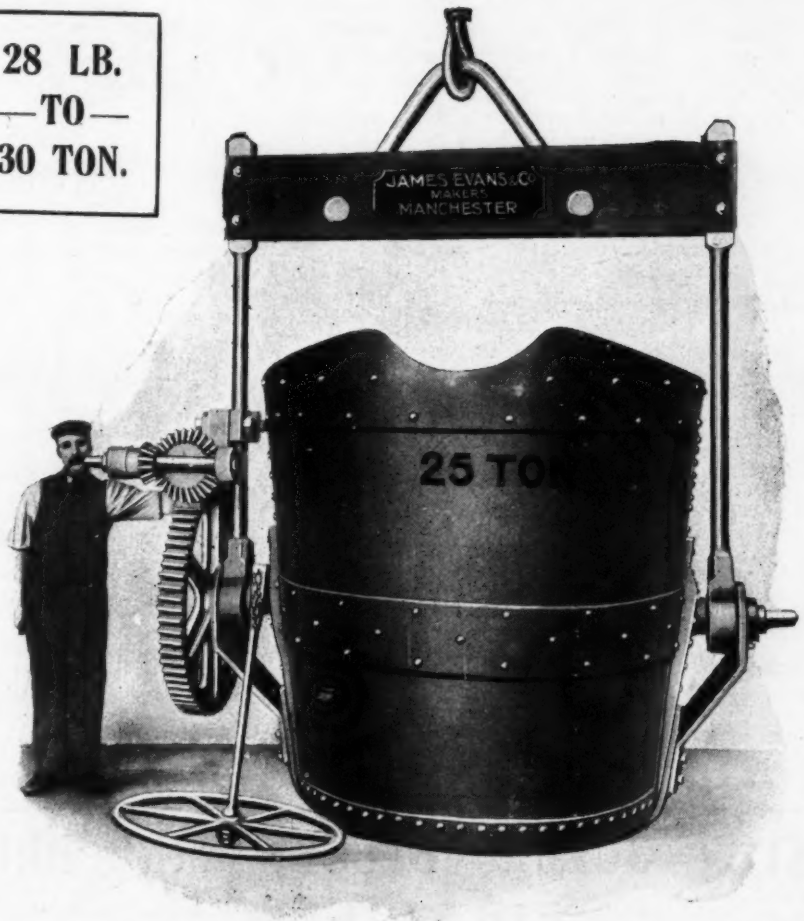
MR. T. CRAWFORD died recently at his residence, 10, Haldane Terrace, Jesmond, Newcastle. The deceased gentleman was born at Byker, Newcastle-on-Tyne, on November 9, 1825. He was the sixth son of the late Mr. Wm. Crawford, who was manager of the foundry department of the now defunct firm of Messrs. Losh, Wilson & Bell, Walker Iron Works. In 1854 he entered the office of Messrs. C. Mitchell & Company, shipbuilders (now Sir W. G. Armstrong, Whitworth & Company, Limited), with whom he remained until his death.

THE death is announced of Mr. G. Gore, F.R.S., LL.D., at his residence in Easy Row, Birmingham, in his eighty-third year. Mr. Gore was born in Bristol in 1826. In 1851 he removed to Birmingham, where, for a short time, he was employed as timekeeper at the Soho Works. For a few years he practised medical galvanism, and in 1852 he made and published researches in electricity, electro-metallurgy, and chemistry, and began teaching classes in the subjects of electro-plating and chemistry. In 1855 he made numerous experiments in electro-metallurgy, and discovered the remarkable substance known as explosive antimony. In 1863 he invented a small gas furnace, in which cast-iron could be melted without the aid of a blast of air. This furnace has been extensively used for experimental and technical purposes.

WE regret to announce the death of Dr. Francis Elgar, chairman of Cammell, Laird & Company, Limited, formerly managing director, and more recently chairman of the Fairfield Shipbuilding and Engineering Company, Limited. The deceased gentleman was born at Portsmouth on April 24, 1845. He was educated at the Royal School of Naval Architecture and Marine Engineering, and in 1867 became a Fellow of that institution. He was in the Admiralty service from 1867 to 1871, when he became chief profe-sional assistant to Sir E. J. Reed. In 1881 he began to practise in London as a consulting naval architect. In 1886 he relinquished this post, and gave up his private practice to enter His Majesty's dockyards at the Admiralty. Six years later he was appointed Director of and Naval Architect to the Fairfield Shipbuilding and Engineering Company, of Glasgow, and became chairman of the Company in 1907. In that year also he took up the chairmanship of Cammell, Laird & Company, Limited, at the time of the reconstruction of the Company. Mr. Elgar was an hon. LL.D. of the Glasgow University, a Fellow of the Royal Societies of London and Edinburgh, the Society of Antiquaries, and the Royal School of Naval Architecture and Marine Engineering, Vice-President of the Institute of Naval Architects, Hon. Member of the Society of Engineers, Member of the Council of the Institution of Civil Engineers, the Royal Institution, the Royal United Service Institution, the Institution of Engineers and Shipbuilders in Scotland, the Association Technique Maritime of France, and the Naval Institute of America; and he was a Chevalier of the Legion of Honour.

FOUNDRY LADLES.

28 LB.
—TO—
30 TON.



JAMES EVANS & CO., BRITANNIA WORKS,

TELEGRAMS—
"LADLES, MANCHESTER."
TELEPHONE—2297.

BLACKFRIARS, MANCHESTER.

QUERIES.

Slow Melting.

I should be glad of your opinion on the following:—My furnace is 8 ft. 6 in. high and 18 in. diameter, with three blast holes, one 4 in. and two 3 in.; my fans are 18 in. diameter and 6 in. outlet. But I am not satisfied with the rate of melting, for I get approximately 10 to 12 cwts. of metal per hour. I consider I should get from 20 to 25 cwts. per hour. I think my fans are too small, and propose getting a larger one. What size would you recommend? Regarding the lining, are silica cupola bricks much better than the ordinary firebricks?—"J. B."

Shrinkage Scale.

I should esteem it a favour if you could inform me through your columns, the price of, and where I could obtain a taper scale, as used for measuring the shrinkage of test bars.

"CONSTANT READER."

REPLIES.

Shrinkage in Malleable Iron Castings.

In reply to "V. G.," this trouble is one that cannot be adequately dealt with at a distance, and may arise from any, or all, of the following causes: Highly refractory character of the cores, locality of the gate, height of shrink ball, and distance and thickness of gate between the casting and the shrink ball. This latter, if more than $\frac{3}{8}$ in. distant from, and not equal in thickness to that of the castings, will solidify, before the shrink ball can fulfil its purpose. It is imperative that the shrink ball should stand higher than the casting, be placed as close as possible, with the gate cut in the cope part of the mould, and not cast with cold metal. If the iron is thought to be the cause of the trouble, I would advise a hard grey hematite of the following chemical composition:—Total carbon, 3.7 per cent.; silicon, 1.3 per cent.; Ph., 0.05 per cent.; S, 0.08 per cent.; Mg., 0.35 per cent.; the liquid contraction in an iron of this class will be found much lower, and at the same time be suitable for fittings that do not exceed $\frac{1}{4}$ in. in thickness.

C. E. ALLEN.

Strong Iron Mixture.

The way in which the iron is treated during and after fusion many have a considerable effect on the physical quality of the castings. Unless great care be taken, the best pig-irons may be so weakened as to possess in the finished castings a strength greatly below that of very inferior irons manipulated on correct principles. You will find the following mixtures, other things being equal, low in liquid contraction, and eminently suitable for castings with an average thickness of $\frac{5}{8}$ in.:—

I.	Lbs.	II.	Lbs.	III.	Lbs.
Bestwood No. 1	224	Stanton No. 1 ...	224	Stanton No. 2...	224
Awsworth No.3	336	Awsworth No. 3	336	Stanton No. 4 ..	336
Scrap	560	Scrap	560	Scrap	560

The analyses of the above irons show on calculation after deducting loss of silicon 0.25 and Mg., 0.10 per cent., and a gain of 0.03 per cent. sulphur due to remelting, that the chemical composition of the resultant castings should be as follows:—

I. Si 2.44, Ph. 1.21, S 0.09, Mg. 0.22 per cent.
II. Si 2.54, Ph. 1.23, S 0.082, Mg. 0.238 per cent.
III. Si 2.56, Ph. 1.16, S 0.090, Mg. 0.226 per cent.

Select machinery scrap, see that it is small enough to melt with the pig-iron, and I feel sure that strong castings, with splendid working qualities, will be obtained.

C. E. ALLEN.

A Strong Iron Mixture.

In reply to the inquiry for an iron mixture of a very strong nature, in the first place very strong mixtures for small castings should not be attempted. The casting being small, of different thickness in section, having a body of metal about 2 in. in one part and being cast in such a position that it cannot be fed, shows at once that the trouble is shrinkage and not contraction. To remedy this the thick part needs to be cooled as quickly as the other parts. If it is possible the best way would be to make a chill to the contour of the thick section. This would allow the whole to cool down more evenly and prevent the thick part being liquid when the thin part has set. The castings having to be machined, the hardness from the effects of the chill may be overcome by a composition of steatite, soapstone, and petroleum mixed to a thin paste. Care must be taken to make the gate so that the fall or flow of metal does not go direct on the chill. The present mixture is rather a weak one, but if the Carron is left out and $1\frac{1}{2}$ cwts. of Carnforth used with the same amount of Lackenby and scrap, a stronger mixture would be obtained. Whatever mixture you use unless the parts are cooled more equally, this trouble will occur.

"A MOULDER."

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
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REG. TRADE MARK.

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BROKEN CASTINGS.

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AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From MOUNTFORD PHILLIPS & CO., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

METALS.	End Jan., 1908.	End Jan., 1907.
Iron—Scotch pig warrants ton	*54 4½	*56/3
—Middlesbro' warrants ... ton	48/7½	48 8
—W.C. M/nos Bessemer ... ton	58 6	60.6
—Stock, Scotch ... .. tons	1,000	1,129
Copper—Chill bars, GMB ton	£58 13 9	£61 10.0
—Stock, Europe and afloat tons	54,684	20,660
Tin—English ingots ... ton	£126 15.0	£133 10 0
—Straits ... ... ton	£124 10 0	£130 5.0
—Stock, London, Holland, and afloat ... ...tons	—	15,330
Lead—English pig ... ton	£13 10 0	£15 2 6
Spelter—Ord. Silesian ... ton	£21 12 6	£20 5 0
Quicksilver (75lb)... bottle	£8 7 6	£8 4 6
Antimony—Regulus . ton	£32 0.0	£36 10.0

* Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	6 15 0	to	7 0 0
Pipes, 1½ to 2½ in.	5 2 6	to	5 7 6
,, 3 to 4 in.	4 15 0	to	5 5 0
,, 5 to 8 in.	4 12 6	to	4 15 0
,, 10 to 16 in.	4 12 6	to	4 15 0
,, 18 to 24 in.	4 12 6	to	4 15 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 0 0	to	3 5 0

SCRAP.

The quotations for scrap, subject to market fluctuations. are as follows:—Heavy wrought (mixed), £2 5s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 6s. 0d.; all per ton f.o.b., London. Copper (clean), £55 0s. 0d.; brass (clean), £40 0s. 0d.; lead (usual draft), £12 10s. 0d.; tea lead, £10 15s. 0d.; zinc, £17 5s. 0d.; all per ton delivered merchant's yard.

MESSRS. E. P. ALLAM & COMPANY, of 11, Red Lion Street, Clerkenwell Road, E.C., have removed to 28, Gray's Inn Road, Holborn, W.C.

MR. C. G. CLARKE has been appointed London agent of the Birmingham Metal and Munitions Company, Limited, of Kingsway House, W.C.

THE POWER GAS CORPORATION, LIMITED, has acquired the suction gas producer business of the Mersey Engine and Producer Company, and are considerably developing the business.

IT is reported that the proposed combination of marine engineering firms on the North-East Coast, which has been considered during the last three months, has had to be abandoned owing to the many difficulties as to terms.

MR. E. DICKINSON, managing director of the Hardy Patent Pick Company, Limited, Sheffield; Major T. H. Lewis, of Messrs. E. Lucas & Son, malleable iron-founders, Dronfield; Mr. W. Lucas, managing director of E. & W. Lucas, Limited, spade and shovel makers, Dronfield; and Mr. C. Lowcock, edge-tool manufacturer, Dronfield, have lately been made J.P.'s for Derbyshire.

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OUGHTIBRIDGE.

GROUND GANISTER,

WET OR DRY.

Silco Cupola Bricks, 90% Silica.

Better than Fire-clay Bricks for Cupolas.

Established 1863.

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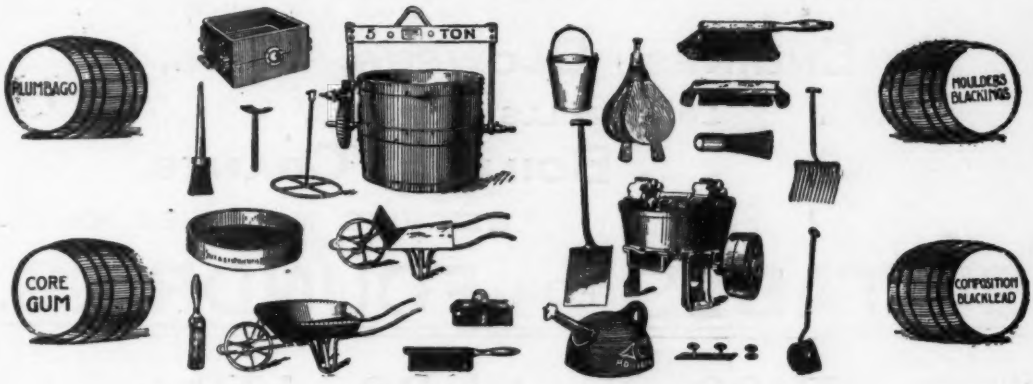

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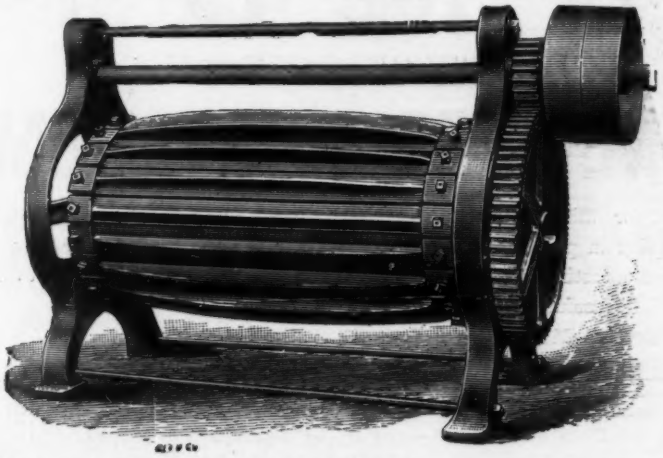

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IT dries on a casting in 1 hour, and can be filed up bright in from 6 to 12 hours.
IT is specially useful to all Engineers, Machinists, Foundrymen, etc.
IT is of British Manufacture.

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185	Elders' Navigation Collieries Ltd. ...	Foundry Coke	Cardiff	Elder, Maesteg	10
138 & 183	Evans, J., & Co.	Foundry Requisites... ...	Manchester	Ladles, Manchester ...	2297
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190	Marshall, H. P., & Co.	Core Machines	Leeds	Specialty, Leeds ...	1909 Leeds
130	McGregor Bros., Ltd.	Moulding Machines... ...	Leigh, Lancs.	Vulcan, Leigh, Lancs....	56
130	McNeil, Chas.	Steel Ladles	Kinning Park, Glasgow	McNeil, Glasgow ...	X 155
186	Olsen, William	Plumbago and Blacking ...	Cogan Street, Hull	—	—
136	Phillips, Chas. D.	Foundry Core Ovens ...	Newport, Monmouthshire ...	Machinery, Newport ...	18 & P.O. 576
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137	Thwaites Bros., Ltd.	Foundry Plant	Bradford	Thwaites, Bradford ..	325 Bradford
134	Walker, I. & I.	Foundry Blackings	Rotherham	—	—
188	Ward, T. W., Ltd.	Cupolas, Loam Mills, &c. ...	Albion Works, Sheffield	Forward, Sheffield ...	189, 1472, &c.
134	Whittaker, W., & Sons, Ltd.	Moulding Machines... ...	Oldham	—	—
136	Wilkinson, Thos., & Co., Ltd. ...	Foundry Requisites... ...	Middlesbrough	Blacking, Middlesbro'	419

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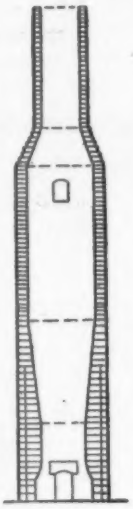

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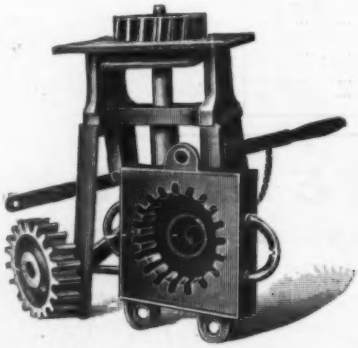

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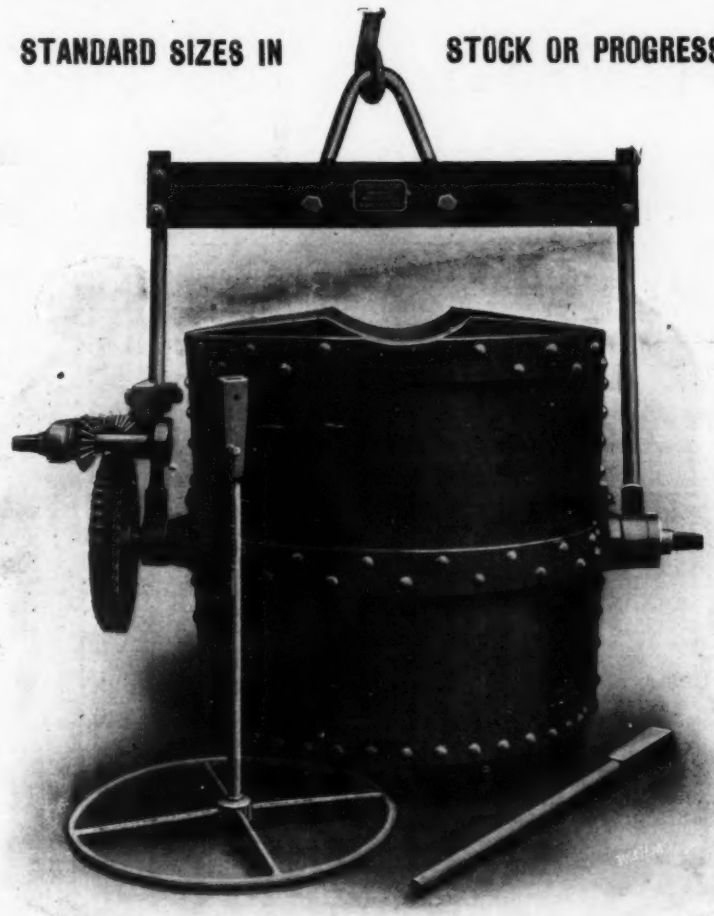

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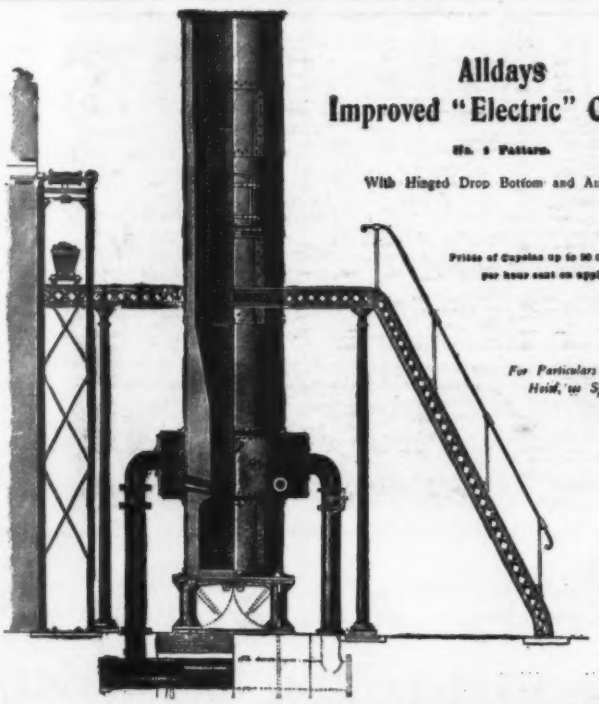

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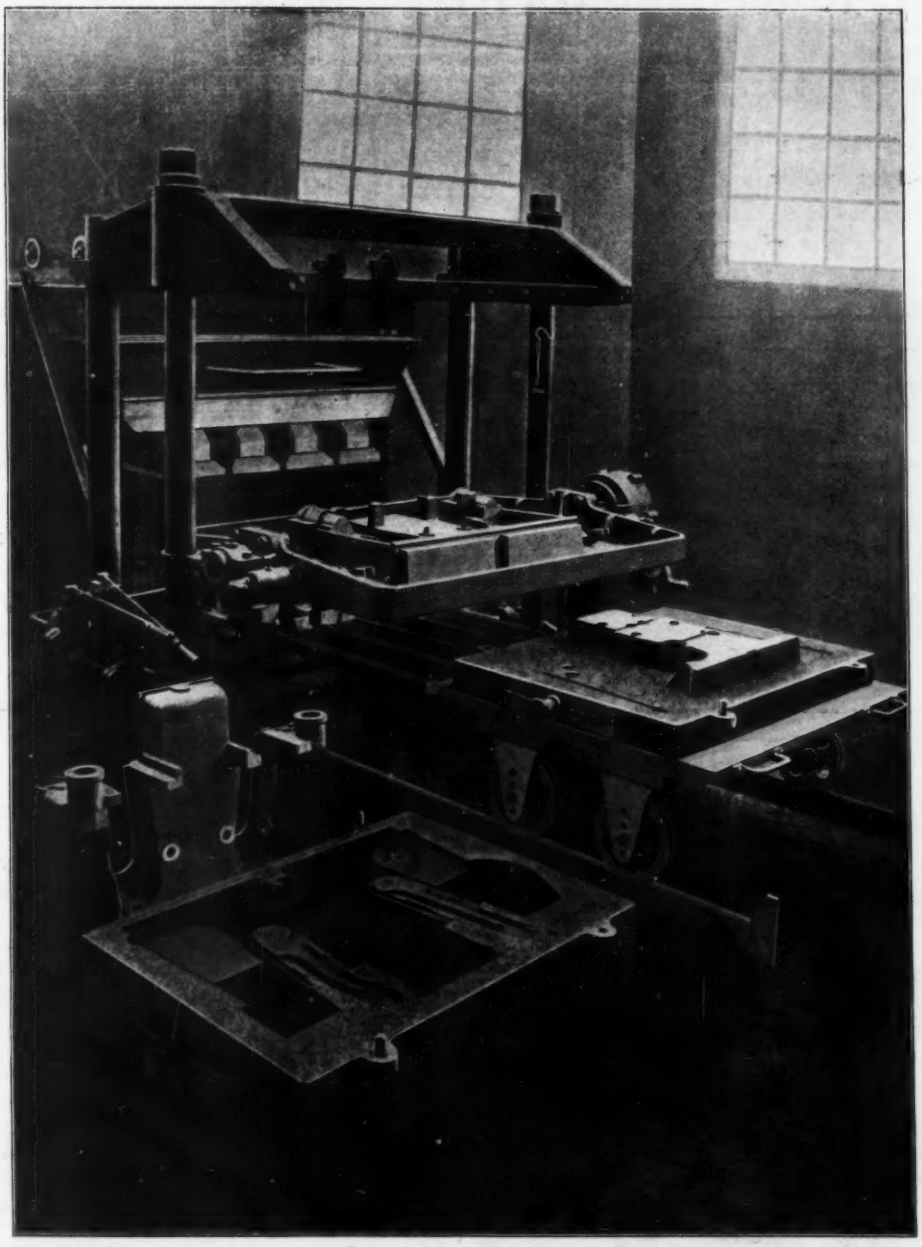

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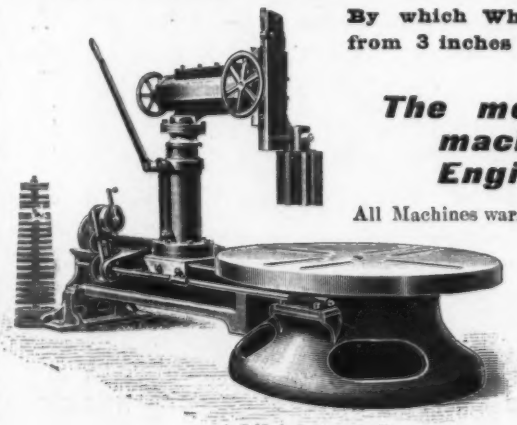

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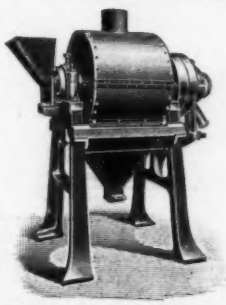

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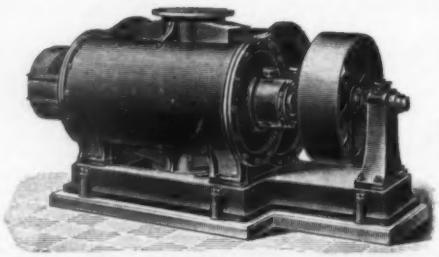

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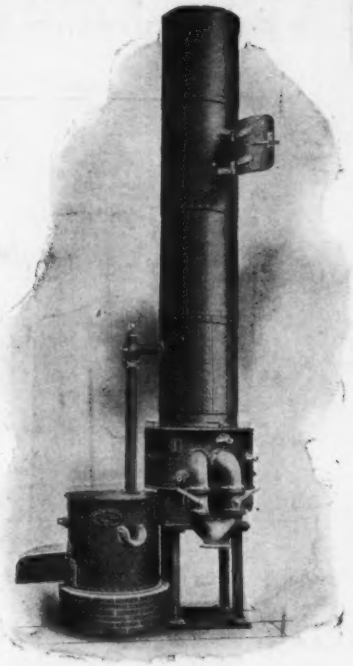

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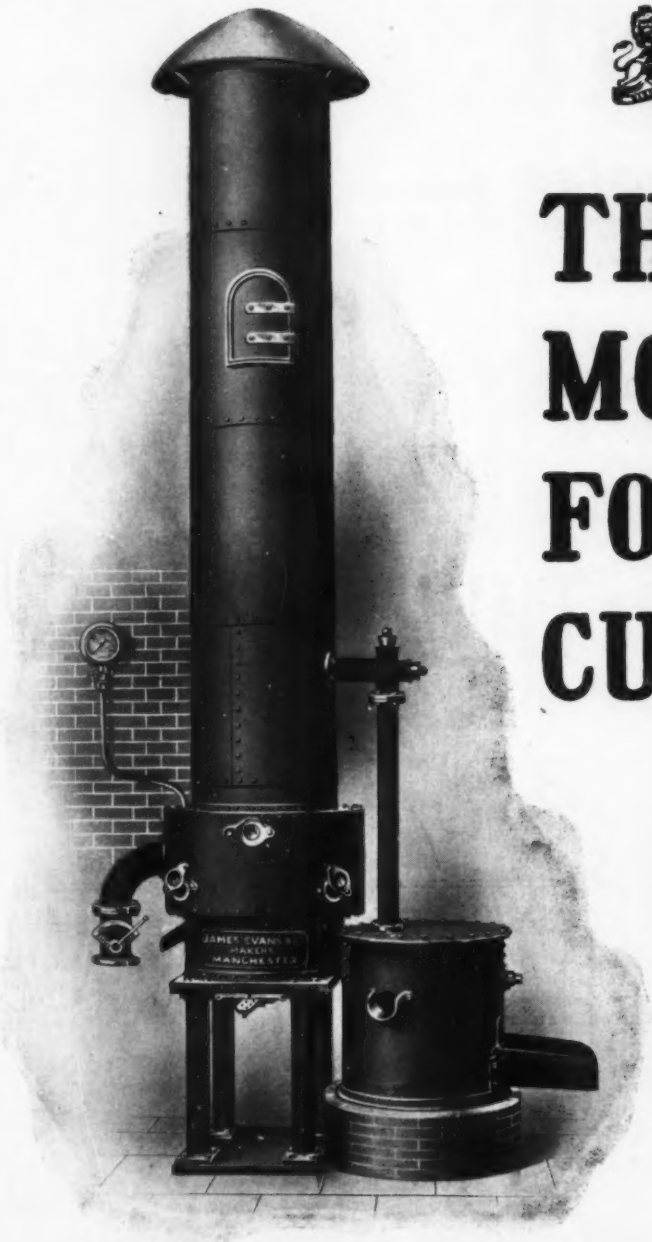

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